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JANUARY, 1923

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ICE JAM IN THE MISSISSIPPI RIVER HELD AT BAY BY A COFFERDAM DURING THE CONSTRUCTION OF THE KEOKUK DAM

Safeguarding a Dam Against Harmful Ice Pressures
Robert G. Skerrett

Painting and Cleaning by Compressed Air Prove Their Superiority
Ray E. Velle

Progress On the Hudson River Vehicular Tunnel
S. G. Roberts

Status of Work On the Delaware River Bridge
J. Hanley Wilkers and A. S. Taylor

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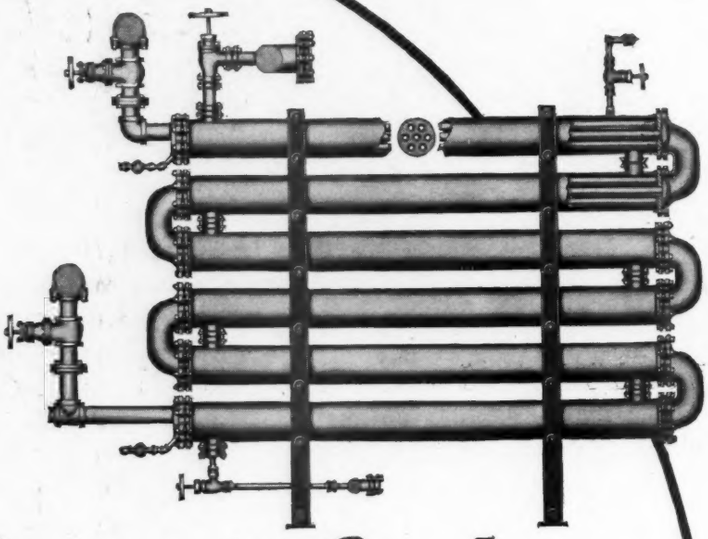
Where Vogt Multitube Ammonia Condensers



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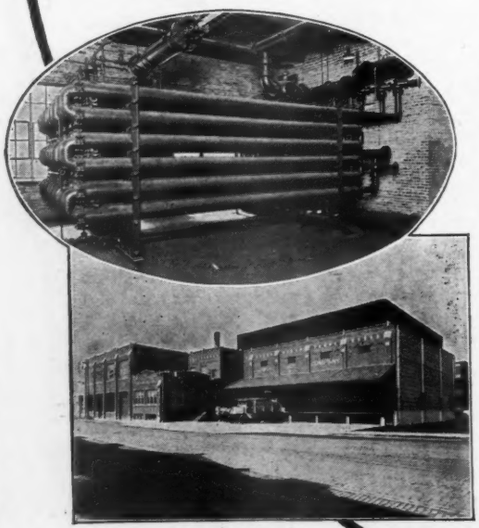

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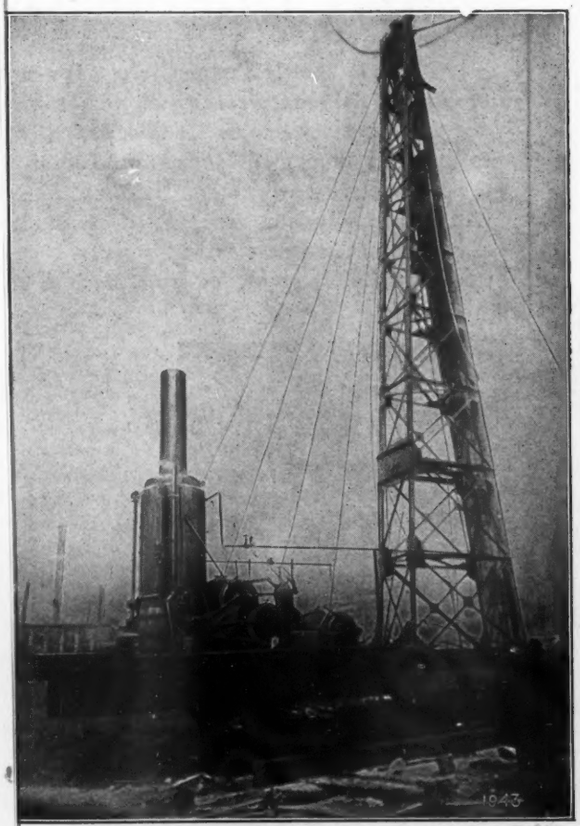

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VOL. XXVIII, NO. I

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JANUARY, 1923

Safeguarding a Dam Against Harmful Ice Pressures

Jets of Compressed Air Prove Strikingly Effective in this Novel Service

By ROBERT G. SKERRETT

IN THE FINAL hours of the last day of June, 1913, the switches were thrown and current was turned into the wires radiating from the hydro-electric plant of the Mississippi River Power Company at Keokuk, Ia., and energy was then transmitted to St. Louis, 144 miles away. Thus was brought to a successful climax strenuous labors covering a period of 2½ years; and the downward sweep of the Father of Waters was halted long enough at that point to make it possible to deliver the first block of an ultimate output of 200,000 horse power.

As may be recalled, to achieve this splendid result, it had been necessary for the engineers to rear, among other things, a great dam of concrete squarely across the path of the Mississippi. Including abutments, this structure has a total length of 4,649 feet, is 42 feet wide at the bottom, and 29 feet across at the top, and rises to a height of 53 feet above the rocky bed of the river. The dam is composed of 119 arched spans, with piers six feet thick, and with an open space of 30 feet between each pair of them. The spillway sections are each 30 feet long and 32 feet high; and surmounting every spillway section there is a steel gate 32 feet from end to end and eleven feet from top to bottom. These gates can be raised and lowered, and by doing so the height of the water in the river on the upstream side of the dam can be regulated.

Before the dam was built, the descending flow of the Mississippi was broken by a series of rapids just above the dam site; and it was no unusual occurrence in the early spring for ice to gather in the shallow waters and to produce a formidable jam. It was well known that normally, for several months of each year, the Mississippi was frozen over from the Iowa to the Illinois shore; and one of the fairly regular spectacular events attending the passing of winter was the violent break-up of the ice which, for days and weeks, would be carried swiftly southward past Keokuk and Hamilton, on opposite banks of the stream. It was because of this yearly convulsion of Nature that the people, dwelling about that section of the river, speculated variously as to what would happen to the dam if the ice was free to act as it had in seasons gone. It was no uncommon thing for the ice to freeze in thicknesses ranging from twelve to 24 inches.

ICE is a source of trouble and a cause of added operative cost to many hydro-electric plants the world over. The extent of this varies with the geographical location of the power station and the severity of the winter season.

Indeed, in some places the accumulating ice fields become actual menaces to certain of the structural features of the installations, and on numerous occasions the responsible engineers have been hard put to it to devise facilities which could be counted upon, with a reasonable promise of success, to neutralize or to minimize the destructive forces set up by the heavy ice.

This article describes how one great hydro-electric plant on the Mississippi River has been safeguarded from the damaging actions of ice; and it is not unlikely that the procedure adopted there may serve as a valuable guide in developing a kindred protective service for other power stations similarly exposed.

However, the engineers expected to so alter the ice conditions by the erection of the dam and associate works that they looked confidently to future winters, and in a measure this attitude was warranted. The dam, by impounding a portion of the Mississippi's volume, was counted upon to form a lake above the dam which would reach up stream a distance of 65 miles, have a width of several miles at its widest part, and be not less than a mile across where narrowest. By submerging the former rapids, this whole area would, of course, be a body of slow-moving and relatively still water. This lake, in other words, was to provide a favorable place, many square miles in extent, in which a great ice floe might develop and remain stationary until it melted away gradually with the coming of warmer weather. Up to a point, and for some time, these expectations were realized, but the confined ice was not as quiescent as the engineers had assumed it would be, and stresses were eventually induced by the ice which reacted injuriously against a number of the spillway gates.

From 1913 on until the winter of 1916-1917, the ice in the river occasioned but little alarm to the men in charge of the Keokuk dam and the associate power plant. The rounded, upstream faces of the bullnoses of the piers and the slight elasticity of the gates, themselves, automatically offset and minimized the initial pressures caused by any movement of the ice. As a matter of fact, the intervening winters had, up to that time, been comparatively mild. But during the cold months last mentioned, owing to a somewhat prolonged period of decidedly low temperature, ice 22 inches thick formed in the river, and it was plain that something would have to be done, and done quickly, to prevent serious damage to the gates.

The magnitude of the forces that came into play then can best be grasped if we tell how the gates were built. They were fashioned of steel-truss framework, faced with plates of the same material ⅜ inch thick, and were designed to withstand easily the cumulative pressure of a head of water mounting to a maximum of eleven feet. The gates move vertically in recesses or guideways, one in each flanking pier. These recesses are fourteen inches deep and 21 inches wide. It might be mentioned here that a force sufficient to bend a gate more than 4¾ inches would prevent the gate being raised past the face of the dam at the crown of an arch. One gate was given a permanent deflection of 2½ inches; and when that occurred the ice exerted a pressure of about 7,400 feet

A view of the upstream face of the dam illustrating the action of the air jets in front of the gates when installed in their final positions.

per linear foot of the dam. The replacement of a gate would entail to-day an expenditure of approximately $3,000.

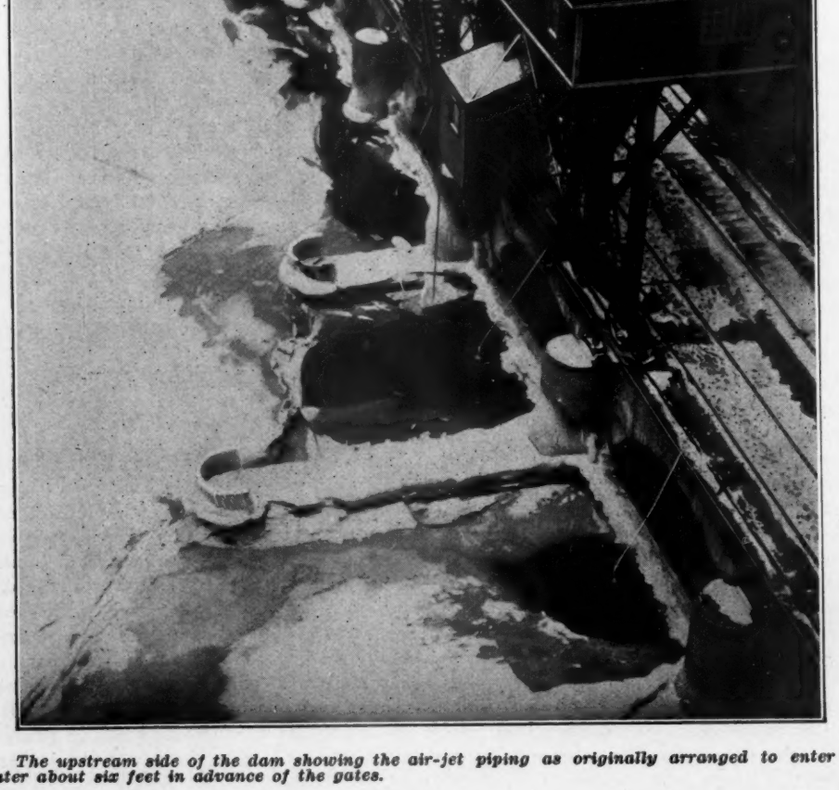
When the situation in January of 1917 was especially disquieting, some relief, of a temporary character, was obtained by using steam to thaw narrow channels in the ice parallel with and in front of each gate. This procedure proved to be a slow and an expensive one, and, withal, rather unsatisfactory because it was impossible with the equipment available to get around fast enough to take care of all of the 119 gates. Some of them were injured and badly bent before a pressure-relieving fissure could be melted in the ice by steam. The menace of the ice emphasized the need of some sort of protective measure, but the question was, What? The experiments with the extemporized steam outfit revealed, at least, some of the factors that would have to be given due weight in devising facilities likely to insure success in combating a heavy ice floe.

Before detailing the equipment finally adopted for dealing with the ice problem at the Keokuk dam, it would not be out of place here to explain some of the physical reactions which are induced by ice under different conditions. Ice is capable of exerting pressure in three ways, and all of these have to be taken into account in order to provide agencies which will safeguard a dam against damaging stresses. Water, during freezing, increases in volume 8.4 per cent., and the incident expansion, if the water be confined, may exert a tremendous pressure. Next, the expansion of a field of ice, by reason of a rise of temperature, can induce a pressure of great magnitude. And, further, there is that possibility of a mass of ice, when in motion, exerting pressure by reason of its inertia—the measure of this depending upon the weight of the body and its speed.

It is not commonly recognized how much ice expands with a temperature rise in the contiguous atmosphere. In this respect it is not unlike a piece of steel, except that the coefficient of expansion of ice is 4½ times that of the metal in question. It is expansion of this nature that produces the more or less pronounced pressure ridges observed in fields of ice at times. In the case of the Keokuk dam it was pressure of this origin that was most dangerous to the structure and had, therefore, to be guarded against with special care. As explained by the experts in charge of the plant of the Mississippi River Power Company: "When ice first forms on the lake, and until it becomes from eight to ten inches thick, the field is pliable enough to take up the expansion when confined. When the thickness becomes greater than this, however, if the ice is hard and solid from prolonged cold, pressures are developed sufficient to buckle or to crush the ice and to allow the field as a whole to expand. This results in ridges of buckled ice, every mile or so along the river, which relieve the internal pressures and allow free play of the field ice for expansion."

Describing further what occurred in the early part of 1917, these authorities say: "The first ridge of buckled ice above the dam formed about a mile north of the dam, making a separate field approximately a mile square. This field, averaging eighteen inches thick, developed pressures which permanently injured several of the gates. Action of this sort depends to a large degree on the condition of the ice. For example, soft, honeycombed ice will not show expansion or develop pressure unless it is very thick. The greatest pressures will be exerted against the dam when ice becomes thick and solid right up to the dam and when there is a sudden rise of temperature combined with considerable fluctuation of the lake. In a case like this, the ice next to the dam will not buckle up and relieve itself, but will work up and down with the lake and produce a dangerous toggle-joint action. This was the case in the winter of 1916-1917."

It should be evident that whenever ice jams form in the lake above a dam, these jams become in effect momentary dams, and the impounded water, reacting against these obstructions to the normal flow, may actually cause the field to move forcibly toward the per-



The upstream side of the dam showing the air-jet piping as originally arranged to enter the water about six feet in advance of the gates.

Showing the effect of pressure and the movement of the ice against the upstream face of the dam. This action is particularly marked around the bullnoses.

manent dam. Accordingly, it is highly important that the ice field, if practicable, be anchored so that it cannot gain headway and advance as a mass against the man-built structure; and this end can probably best be obtained by taking whatever steps may be possible to promote a good bearing of the ice against the dam piers at all times.

Before taking up in some detail the installation as it was eventually developed for the Keokuk dam, let us consider for the moment the conclusions reached by the management of the Keokuk plant after a period of experimenting. As they have expressed it: "Whatever method is used, it should not leave a continuous slot of open water above the dam which might allow the entire field to move suddenly against the dam, but it should clear the ice away from the gates and still leave it in contact with the piers. It is also desirable that the process be a continuous one, leaving no broken up ice, and be under the easy control of a minimum amount of labor."

The object in reducing the area in contact with the dam was two-fold: First, to lessen the pressure on the dam as a whole, and, next, to interpose, in effect, a cushion between the structure and the main ice field. After study and some tests, the engineers decided that subaqueous jets of compressed air could be used effectively to maintain a sufficient zone of open water immediately in front of each gate. It was satisfactorily demonstrated that the submerged discharge of air would induce a circulation of the adjacent water and that this movement, in its turn, would melt any ice present and thereafter check the reformation of it within a given radius—the latter depending upon the volume of air liberated. In principle, nothing could be simpler.

The system was put in operation December 10, 1917, and had at once to contend with a handicap of ten inches of ice on the lake. At the time, the average daily temperature was below 15° F., and yet, within a week, the air was able to melt the ice away from substantially the full width of each gate and throughout a semi-circular area of considerable radius. To keep the outdoor part of the equipment in proper working order required inspection only about every other day. Experience showed that some modifications were needful in certain details of the fittings, and it was also found desirable to reduce somewhat the zone of open water before each of the gates.

A motor-driven compressor located in the power house supplies air to a main extending on top of the dam from end to end. This main varies in diameter from 1½ to two inches, and is run close to the upstream edge of the structure. The piping has interposed in its length six expansion joints which have a total traverse of 90 inches. Their function is to prevent the main from kinking—something that did occur before the expansion joints were installed and when there was a temperature rise of 30° F.

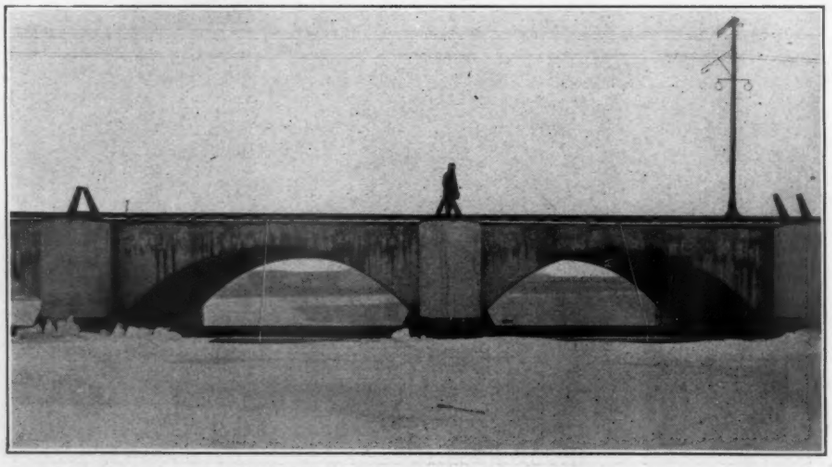
Above the center of each spillway gate, the distributing main is tapped by a ⅜-inch pipe which extends downward and into the water. At each of these connections a ⅜-inch, needle-point valve regulates the flow of the air through the small pipe. In the beginning, the lower end of every pipe carried a cap having a 1/16-inch orifice, and the terminal fitting was formed so as to discharge the air vertically upward. The caps very quickly clogged up and froze, and to avoid further trouble they were removed. This naturally increased the volume of compressed air expelled from the unimpeded outlet of the ⅜-inch piping, but this did not increase to an objectionable measure the amount of compressed air required for the entire service.

At the start, the small pipes were arranged to discharge at a depth of eighteen feet below the surface of the water and at points six feet in front of the gates, but this disposition led to trouble. The air rose from the orifices something like three feet away from the points where the pipes entered the water, and the pipes, during the night, were surrounded with ice. When the level of the lake fell, some of the pipes, loaded and gripped in this manner, were broken loose and carried away. To prevent a recurrence, the small pipes were bent so that they would enter the water close to the

A semi-circular area of clear water, in front of a gate, produced by the action of the ascending air from the submerged nozzle.

Ice, during a spring break-up, which was successfully held in check by a cofferdam during the construction of the plant of the Mississippi River Power Company, at Keokuk, Ia. This explains, in part, why a compressed air protection against ice pressure was later on installed upon the dam.

The dark patches at intervals in front of the face of the dam are areas of ice-free water produced by the air jets as at first employed. These areas generally were larger than desired, as explained in the accompanying text.



A frontal view of the Keokuk dam in December of 1917, when the thermometer averaged daily, for a week or more, about 15° F.

gates and lie in the ascending path of the air bubbles. This prevented the formation of ice about these conduits.

With the pipe outlets eighteen feet under water and six feet in front of the gates, the emitted air caused a too general circulation of the water, and, as a consequence, the erosive action was so widespread that only thin ice formed about the piers where, for the reason already given, it was desirable that the ice be fairly solid in order to insure a good bearing of the field against the dam. Accordingly, the pipes were shortened to ten feet and adjusted so that they would discharge about a foot in front of each gate and six inches above the crest of the spillway. These alterations reduced the area of open water at each gate to two-thirds the width of that structure, and brought about a condition calculated to best safeguard the gates and the dam, itself. Let us make this clear.

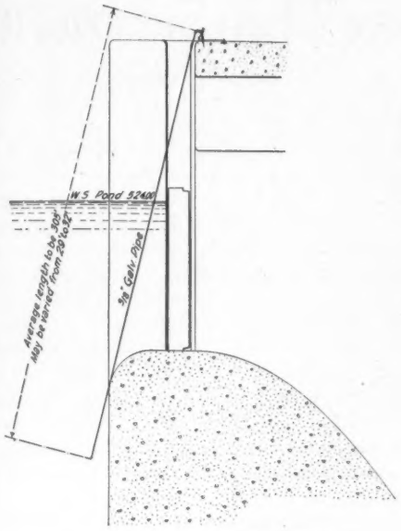
The engineers tell us that when the middle two-thirds of each gate is kept free of ice and the main body of the field is allowed to remain in touch with the piers and against about five feet of the gates on each side of the piers then the conditions are most favorable. That is to say, this control of the ice not only eliminates the danger of failure of the gates by thus removing the pressure at the center of them, but it also reduces the total pressure against the dam, as a whole, by about 65 per cent.

The reason for this, so the experts inform us, is because "the pressure an ice field can exert is limited by the crushing or buckling strength of the ice with which the dam is in contact." Or, to quote once more, "The total pressure against the dam then is the product of this crushing strength by the cross-sectional area of the ice pressing against the dam. If this area be reduced two-thirds, as in the case of the new system, then the total pressure will be lowered proportionately. In actual operation it is believed that the pressure is cut down even more, since the bullnoses act to break up the ice sooner than would be the case if the ice were pressing against the plane surface of the gates."

Manifestly, if the ice field is allowed to have a good bearing against the piers, any sudden movement of the entire ice field is prevented, and there is no chance for that body to deliver a hammer-like blow.

Perhaps it will be of interest to give further particulars about the compressed air equipment. On leaving the compressor, the air passes directly into a receiver, through the receiver, and thence by a 5-inch main, 250 feet long, to a second receiver. From the latter it travels through 350 feet of piping, of from four to five inches in diameter, before arriving at the air drying apparatus. The aftercooler is capable of removing, by condensation, approximately two-thirds of the moisture carried by the air.

On leaving the aftercooler, the air passes through a Mason pressure-regulating and reducing valve. This valve serves to dry the air still further and, at the same time, to insure a steady pressure in the distributing main on the dam. The drying of the air is promoted by a reduction of pressure while traversing the



TYPICAL SECTION
PIPING ON DAM

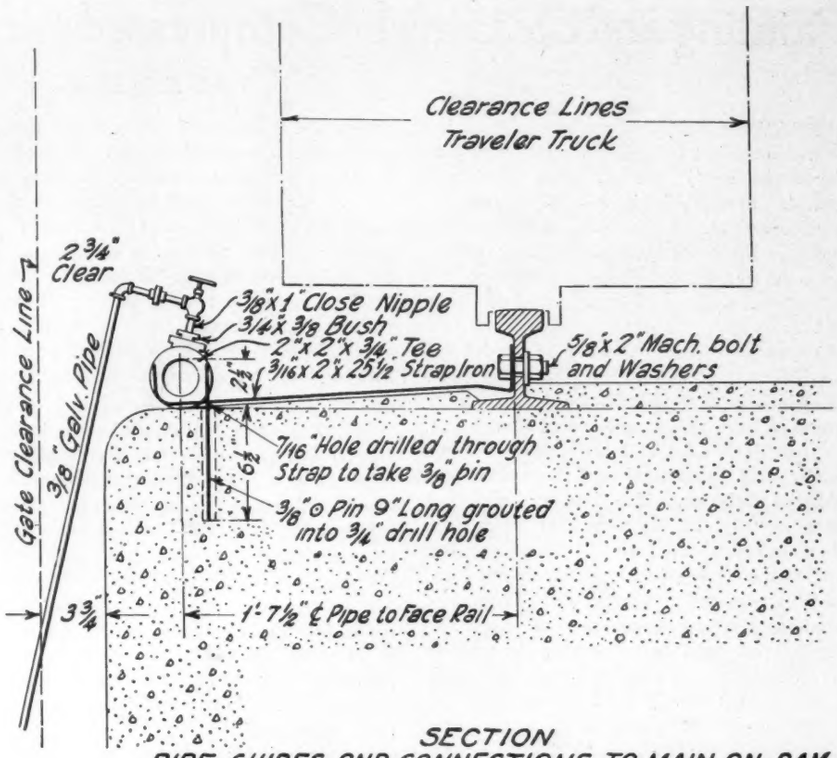
valve—this drop inducing condensation. A receiver, installed next to the regulating valve, collects the precipitated moisture. The receiver is insulated with three inches of corkboard, so that temperatures below that of the interior of the power house may be maintained. The piping from this receiver is insulated with 2-inch corkboard throughout its length until it pierces the wall of the building and reaches the open air.

The compressor, which is driven by a 100-H. P. induction motor, has a capacity of 520 cubic feet of air per minute. When in service, it runs at an average of 90 pounds gage pressure, and this is reduced to 70 pounds at the pressure-regulating valve on the dam main. As would be expected, the moisture-removing equipment has, under these conditions, been worked at only about two-thirds of its designed capacity, but, even so, the aftercooler, which has done practically all of this work, has kept the moisture content sufficiently low to obviate any freezing of the pipes. The installation was originally intended to operate at 125 pounds on the high side, but experience has disclosed that this would not be necessary.

In the preparation of this article, the author has been generously assisted by Messrs. Hugh L. Cooper & Company, who were intimately identified with the building of the Mississippi River Power Company's ambitious undertaking at Keokuk. About three years ago the manager of the plant, Mr. C. A. Sears, made this illuminating statement: "The system is continuing to work to the greatest perfection, and while there is at the present time eighteen inches of ice on the lake, and this ice is shoving up on the bullnoses of the dam to a greater extent than any previous winter, the gates are fully protected, and there is little doubt in my mind that we would have great difficulty in preventing the loss of several gates this winter if it were not for the system which we are using."

In further confirmation of the success of the compressed air installation for preventing ice pressure, Mr. Sears declared in October of the year just closed: "There has been no change in the procedure used in handling this problem from that given in our latest report. The last two winters have, however, been rather mild and at no time have ice thicknesses exceeded nine or ten inches at the dam. Of course, this condition called for a much smaller amount of air to free the gates from pressure than would be required in a winter when ice thicknesses reached eighteen or twenty inches. I think it is now safe to say that about 120 cubic feet of air per minute is sufficient to relieve all gates of the dam from ice pressure even in the most severe weather."

In conclusion, it might be mentioned that the whole compressed air installation involved an outlay of about $9,400—a little more than the cost of three spillway gates; and we are authoritatively informed that $100 will ordinarily cover the charge for labor in connection with the equipment during a whole winter.

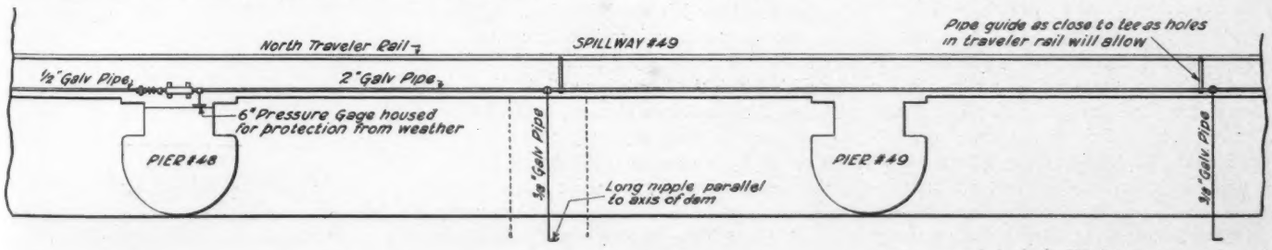

Clearance Lines
Traveler Truck
2 3/4" Clear
Gate Clearance Line
3/8" Galv. Pipe
3/8"x1" Close Nipple
3/4"x 3/8" Bush
2"x2"x 3/4" Tee
3/16"x 2"x 25 1/2" Strap Iron
5/8"x 2" Mach. bolt and Washers
2 1/4"
7/16" Hole drilled through Strap to take 3/8" pin
6 1/2"
3/8" ø Pin 9" Long grouted into 3/4" drill hole
3 3/4"
1'-7 1/2" ℄ Pipe to Face Rail

SECTION
PIPE GUIDES AND CONNECTIONS TO MAIN ON DAM

CENTENARY OF THE STEEL PEN

THE centenary of the founding of the steel pen trade was celebrated not long ago by a dinner in Birmingham, England. On that occasion, Mr. Henry Mitchell said that in 1820 his grandfather was a manufacturer of knife blades and other metal goods, but that in October, 1822, the first sale of steel pens was made, the price being 36 shillings per gross—about 6 cents apiece. Before that date steel pens were scarcely known and cost about 36 cents apiece. Notwithstanding the widespread use of the typewriter, there are now eleven factories in Birmingham making steel pens. Stainless steel should be just the thing for steel pens; but its effect on their manufacture is difficult to predict. The pens of this material should last longer and reduce the demand; but, on the other hand, when in use they should be so much cleaner and better as to greatly increase their sale.

In the Netherlands the manufacture of leather belting, next to that of boots and shoes, is the most important branch of the leather industry.


North Traveler Rail
SPILLWAY #49
Pipe guide as close to tee as holes in traveler rail will allow
1/2" Galv. Pipe
2" Galv. Pipe
6" Pressure Gage housed for protection from weather
PIER #48
3/8" Galv. Pipe
Long nipple parallel to axis of dam
PIER #49
3/8" Galv. Pipe

PLAN
PIPE MAIN ON DAM AT SPILLWAY #49

Painting and Cleaning by Compressed Air Prove Their Superiority

By RAY E. VELIE

SPRAY PAINTING by compressed air has, within the last few years, almost entirely replaced the costly and inefficient hand-brush method. Particularly is this so in factories, machine and car shops, bridge and locomotive works, and in automobile plants; and building contractors now rely almost entirely on this system in the case of big structural undertakings.

In general, spray painting can be divided into two distinct classes. Of these, stationary painting, which is partly illustrated and described here, is probably the one not so well known and, therefore, least used, and yet it offers a much broader field for general application than does industrial finishing. The industrial finishing method usually calls for a spraying room, completely equipped, from the compressed air line down to the fume exhausters. The parts to be painted are moved into this room; placed on a swivel-top turntable when size and shape permit; painted, and then taken from the room to dry. This system of painting is most commonly as well as extensively used in the furniture and the automobile industries where the parts are small or of medium size, more or less symmetrical in shape, and easily handled. This method is also used for spraying enamel paint on kitchen ware, table tops, brick, terra-cotta, etc.

However, stationary painting, that is, painting railroad cars, the exterior and the interior of buildings, ships, structural steel, locomotives, and the parts of stationary engines which sometimes weigh many tons, represents quite another problem. In this case it is obvious that the painting outfit must be brought to the job and not the job to the painter.

The exterior of the metal-sheathed factory, shown in one of our illustrations, was cleaned and painted by the two men and by the use of compressed air in approximately 100 working days. By the aid of a 60-foot hose extension, connected with the compressed air lines already installed, it was possible to lead air to practically all parts of the work; and air at approximately 90 pounds pressure was thus obtainable for operating the cleaning brush and the paint spray. While the work was in progress, it was found that several small, outlying buildings and some fences were too remote from the pressure lines to permit the use of the regular extension hose. In order to save time and expense, a small, portable compressor was sent to the job, after which cleaning and painting by air were continued uninterruptedly and without resorting to the slower hand-brush procedure.

The system used by these two men in cleaning and painting the outside walls of the building in question is unique in that both operations were performed from the same scaffolding, and at the same time: the painters covering practically the same surface without delaying or interfering with each other. Working on a 12-foot scaffold, swung from sharply pointed hooks by means of a two-strand block and tackle, a downward sweep twelve feet wide was finished at each placement. At every new location the painter would confine his work to the window sashes until the man with the air brush had cleaned enough of the surface to warrant the painter shifting to that area. Thus the cleaning was always far enough in advance of the painting to obviate keeping the painter waiting. The cleaner, who, of course, completed his work first, then finished "running," that is, painting, the window sashes before moving the scaffold.

Including sheds, fences, and main buildings, 150,000 square feet of surface was painted; and, in addition, it is estimated that 60,000 window sashes were run. The entire job consumed 350 gallons of paint: one gallon covering on an average 430 square feet of surface. This does not take into account the hand running of the window sashes, which, in itself, is quite an item. It was found that the paint spray worked equally well with air pressures varying from 40 to 100 pounds per square inch, thus giving ample evidence of a wide range of adaptability. From four to seven cubic feet of free air per minute were required for operating the paint spray, depending upon the air pressure.

A "Little David" No. 6 drill, used in cleaning the surface preparatory to painting, was equipped with a wire brush, about six inches in diameter, made especially for cleaning metal surfaces. The average life of the brush was found to be only three days, after which, being beyond repair and inexpensive, it was thrown away and replaced by a new one. The air drill operating the wire brush was far more efficient than a wire hand-brush because it cleaned off not only the dirt but also took off with it the old paint, rust, and grease. The fresh paint was then put on clean metal and not over old paint or grease, which in the past has proved very unsatisfactory. The air drill employed is rated by the manufacturer as requiring nineteen cubic feet of free air per minute at 90 pounds pressure. The man operating the cleaner found that the brush cleaned fully as well at 60 pounds pressure as it did when working at pressures up to 100 pounds.

To sum up, the advantages of the air-driven cleaning brush are so many and so obvious that only a few need be mentioned. A man with an air brush, as shown in the illustrations, cleans four times as much in the same period as one operating a wire hand-brush. Furthermore, the cleaning is thorough, and not a case of merely brushing off the dirt. Hand brushing is a back-breaking job which involves much standing around, and, therefore, lost time—the success or failure of it depending entirely upon the vigor with which the brush is applied. The operation of the air-driven cleaning brush is simple enough: it is necessary only to turn the air on or off by a squeeze of the trigger.

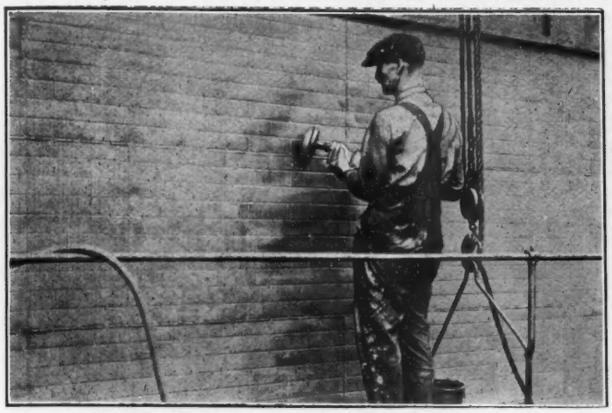
The man using the air paint spray was able to cover fully twice as large an area per day as he could have done had he used the hand-brush method. Besides, the paint spray was more economical in the use of paint, averaging 430 square feet per gallon, and it put the coat on slightly heavier and much more evenly than is praticable with the hand brush. This is due to the fact that there is no loss of paint by drops or "slop" of the brush, and to the better covering qualities of paint applied by air spray. The spray automatically does away with any laps, brush marks, or skimped places, so common to hand-brush painting. It is believed that if there had been no window sashes to run, the job could have been finished in one-fifth the time required to paint the buildings by hand brush—in other words, it is estimated that for straight surface painting the air paint spray is about five times as rapid as the hand-brush method.

The interior views that are shown, illustrate the painting of completed parts in a large shed where the assembled products are given a finishing coat of paint prior to crating and shipment. Inasmuch as the parts or the complete machines sent to this paint shop sometimes weigh several tons, a system of stationary painting is employed. That is, the machines to be painted are placed on the floor of the paint shop, painted, and there allowed to remain until dry, after which they are moved to the shipping department. The painting of these machines consists of a series of preparatory coats of anti-rust fluid and filler, which is applied to all parts of the units except the machined surfaces. A coat of shellac is then put on by air paint spray, and on top of this is sprayed a coat of finishing paint. One of the most important advantages of spray painting over the hand-brush method is the ease with which the thickness of the coat can be regulated.

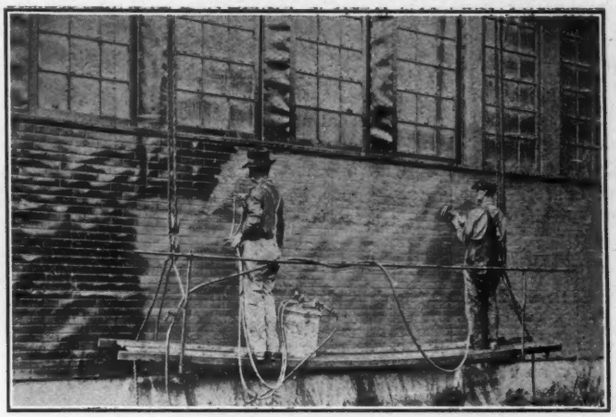
Spraying nozzles of a dozen different types and sizes are obtainable which may be adjusted by simply turning a nut with the fingers so that either a wide fan-like spray or a narrow, concentrated spray can be had—the latter for use on small pieces. The different sized nozzles available can be used with fluids ranging from the thinnest shellac to the thickest filler or enamel. Where the nature of the fluid warrants it, an air-operated agitator is used to keep the solid matter in suspension as, for instance, in applying bronze or similar mixtures. Furthermore, fluid containers can be had in any size from the small 1-ounce cup to the 10-gallon separate container equipped with an air agitator.

As has been said, air-spray painting covers the surface smoothly and evenly and without streaks, fatty edges, or the brush marks so common in hand-brush painting. Thin edges and corners, as well as elaborately carved pieces of work, can be dealt with in a remarkably short time and without calling for special skill on the part of the operator.

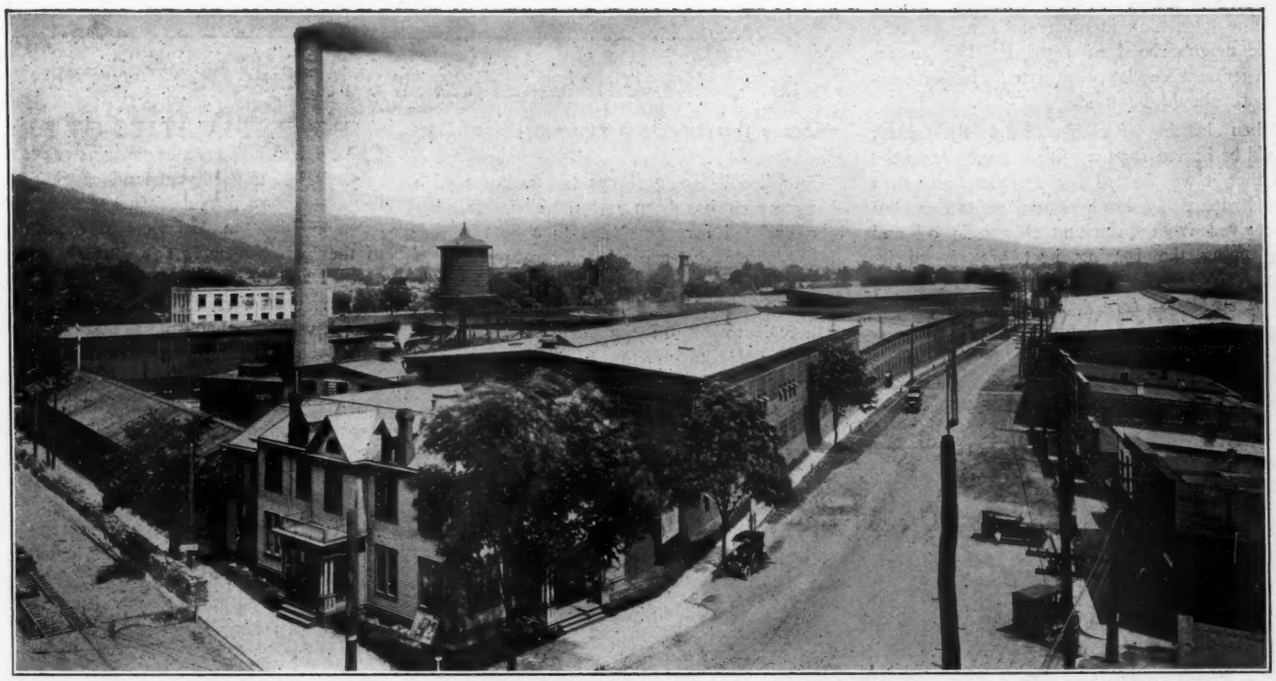
Italy has 868 merchant steamers, with a gross tonnage of 2,539,833, a gain of 224 vessels over her prewar fleet despite war losses amounting to 218 ships.



A close-up of the air-driven wire brush in action. With a brush of this sort a man can clean, in a given time, an area four times as large as he could if he used a hand brush.

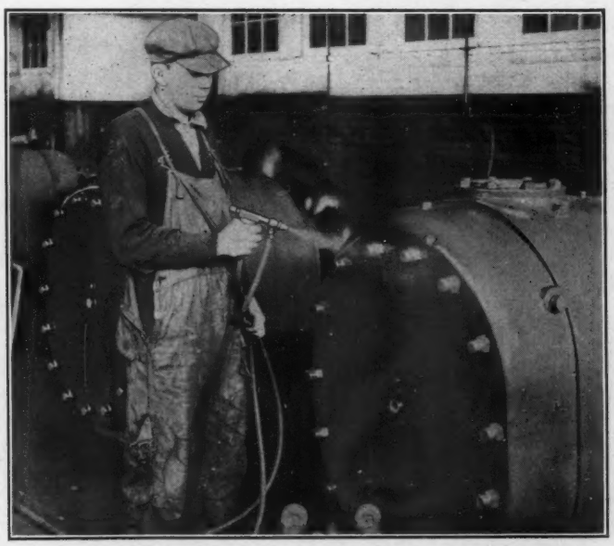


In cleaning and painting a metal-sheathed exterior, these men were able to do their work rapidly and well by means of a pneumatic drill equipped with a wire brush and a paint-spraying outfit.



The exterior of these metal-sheathed factory buildings was cleaned and painted by two men, using compressed air, in approximately 100 working days.

In the shop. Giving the interior surfaces of a machine a finishing coat with the paint spray.



The paint spray used to speed up the application of the finishing coat to machinery.

TEMPERING OF DRILL STEEL

By H. S. BRAINERD

IN THE November issue of the Magazine, the subject of drill steel—its forging and heat treatment—was discussed at some length, but since then it has been suggested that it might be well to deal with another phase of the matter, namely, the proper handling of drill shanks during heat treatment. The present article is therefore offered as an amplification of the earlier paper.

The average user of drill steel does not appreciate the importance of properly heat treating the shank, in fact, he gives the matter little or no thought. The tempering should be gaged with sufficient care to make sure that the shank will not be so soft that it will stick in the rotation sleeve or so hard as to cause the breakage of the drill piston. This is best accomplished, for a 7/8-inch hexagon, hollow steel, by quenching in oil from a temperature in the neighborhood of 1470° F. For shanks of larger sections, however, a trifle higher temperature should be used.

When heating for hardening, the shank should be heated for the same distance from the end that it was heated for upsetting, and then quenched entirely in oil. The benefits that may be derived from quenching shanks in oil and overlapping the forging heat are shown by photograph No. 1. The coarse, brittle fracture of the shank, as forged, compares most unfavorably with the fine, tough fracture of the oil-treated shank. It can readily be seen that short heating for hardening or failure to overlap the forging heat will lead to increased breakage whenever that all-important matter is neglected.

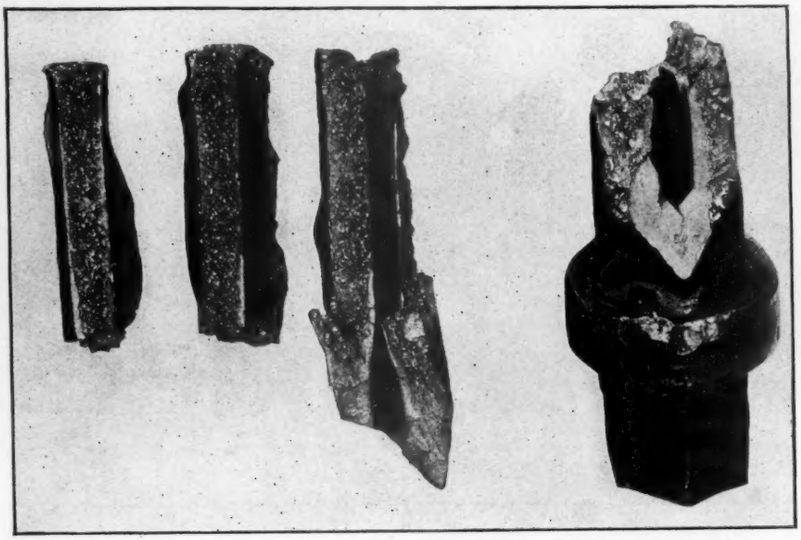


Fig. 2

The fractured sections of a shank illustrating the effects upon the steel of excessive heating. The grain structure indicates that the metal has been burnt.

Photograph No. 2 shows the fracture of a shank which has been burnt. This steel has been exposed for some time to a heat considerably above the critical temperature. Steel in this condition cannot be restored, and is, therefore, worthless. The only thing to do with it is to cut off the burnt shank and to form a new one—seeing to it that forging and heat treating are done at a proper temperature.

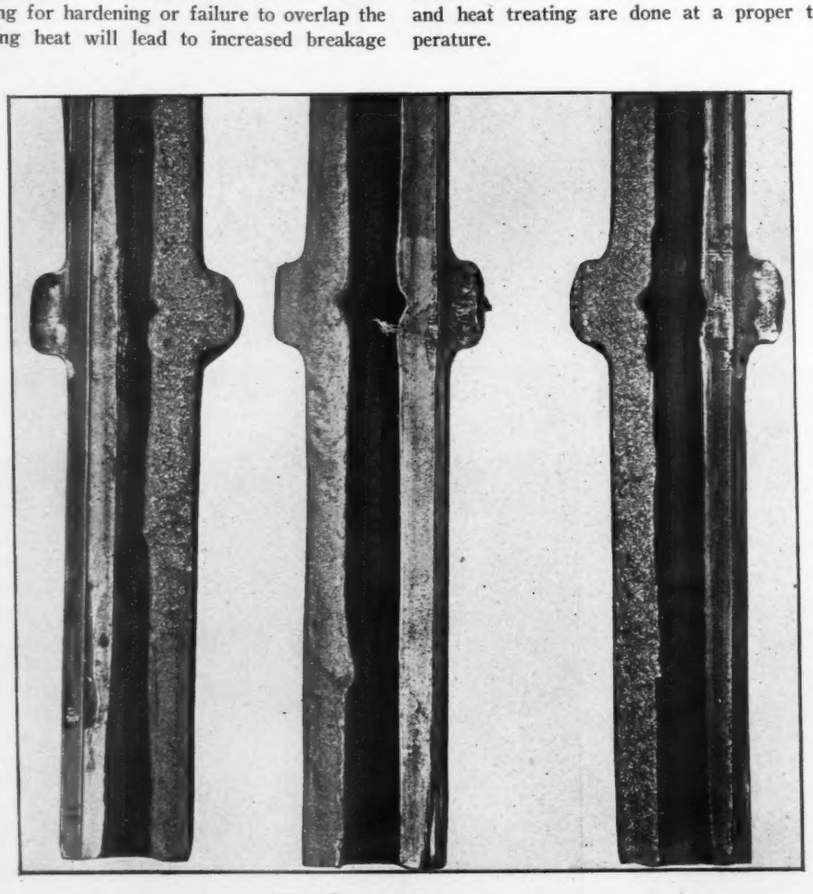


Fig. 1

Forging heat not overlapped. *Forging heat overlapped.* *As forged. No treatment.*

POTENTIALITIES OF PEAT

THE UNITED States contains 12,000 square miles of unused peat land, capable of yielding 14,000,000,000 tons of fuel at a cost of from $1.50 to $5 a ton. In view of the seriousness of the fuel problem in this country, both so far as coal and oil are concerned, this question of drawing upon our resources of peat for domestic consumption should be of interest, especially in view of the fact that peat has been burned for decades past in Europe. Something like 50,000,000 tons of this fuel is now used there annually. A very exhaustive study, from our point of view, has been made of this subject by the United States Geological Survey, and that Bureau has just issued a bulletin, No. 728, on "The Occurrence and Uses of Peat in the United States."

In connection with this matter, Germany has conducted some very successful experiments having for their purpose the extraction of gas from peat. This is just one of the many substitute measures adopted by that nation in the reconstruction of its economic life. In the utilization of this product for power two fundamental difficulties are involved—the high percentage of water and the unfavorable granulation. Though the water content can be reduced by air drying, the amount of moisture remaining is objectionable.

The best way to use the gas produced from peat is first to extract the water by cooling the gas. The resultant gas is said to yield a higher temperature than that obtained through the combustion of bituminous coal. Great difficulty was at first experienced with the distillation of tar products, which condensed easily, and caused disturbance when using the gas in motors. This was readily overcome, however, by separating these valuable tars from the gas. Work has progressed so far that coal-gas furnaces have been converted into peat-gas furnaces.

Cleveland, O., has some 3,000 factories which manufacture annually about 125,000 different commodities, for domestic and foreign consumption, valued at $1,000,000,000.

THE GOOD ROAD SHOW IN CHICAGO

THE FOURTEENTH National Convention of the American Road Builders' Association and Highways Industries Exhibit will be held this year, as usual, at the Coliseum, Chicago, Ill., from January 15 to 19, inclusive. The ever-increasing activity in the construction of new roads and in the maintenance of existing highways and streets is causing from season to season more and more interest in the Good Road Show.

We are authoritatively informed by Mr. Thomas H. McDonald, Chief of the Bureau of Public Roads of the United States Department of Agriculture, that greater progress has been achieved in providing the means of highway transportation during the fiscal year ending with the 30th of June, 1922, than in any similar period in the history of the nation. He tells us in his latest annual report that practically 10,000 miles were added to the Federal-aid road system and probably another 10,000 miles by the various states without Federal help. In large part this development is due to a real public appreciation of the importance of maintaining the roads that are built as well as to a proper evaluation of expansion and improvement.

Under the circumstances, the forthcoming event at the Coliseum may be expected to attract wider attention and to carry its object lesson home to a larger number of our citizens than has been the case heretofore. Last year the exhibit was considered by many the most successful show that had been held during the twelvemonth. This opinion was not based alone on the record attendance and the character of the exhibits but also on the monetary value of the sales then made.

An exposition of this character, in order to be really beneficial to all concerned, calls for the display of a large amount of heavy machinery. At the preceding Good Road Show. the different manufacturers of road-building equipment exhibited the biggest of their products, and in many cases these machines were actually operated for the purpose of demonstrating their service value. The man interested could then see for himself the various types in action, even run them himself, talk them over with his friends, and then decide understandingly which of them would best meet his particular needs. There is no doubt whatever that that procedure has had its helpful effect in promoting the movement for better roads and in speeding up the building of the public highways.

We are told that the show this year will be even bigger and better than heretofore, and there is reason to believe that no one interested in road building—such as government, state, county, and municipal engineers, members of highway departments and commissions, contractors, etc.—can well afford to overlook the forthcoming opportunity to get a comprehensive and a definite idea of the equipment which is at their disposal and the improvements which have been made to aid them in building the best roads for the least expenditure of the taxpayers' money.

We understand that the Ingersoll-Rand Company is to exhibit its well-known line of portable compressors. These machines are self-contained, compact, complete, and mobile outfits, which, not infrequently, have been termed "the road-builder's choice." The same company intends to show different types and sizes of "Jackhamer" rock drills, paving breakers, pneumatic clay diggers, "Leyner" drill steel sharpeners, air hoists, and pumps—in fact, all of its various air-driven tools, which constitute an essential part of every road-builder's working equipment. These labor-saving appliances are mostly light-weight, one-man tools.

Compressed air has been a boon to the road builder; and as far as may be practicable it is likely that the manufacturers will show their apparatus in action so that "the man from Missouri" can see for himself and be convinced of the merit of the pneumatic equipment now placed at his disposal.

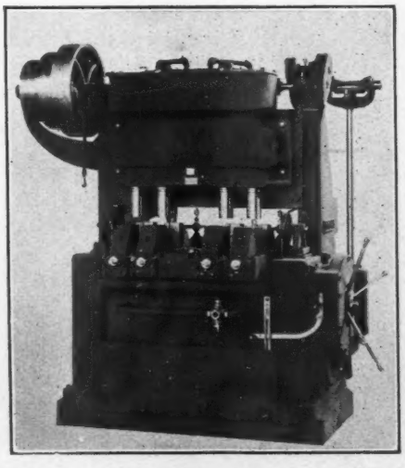
BORING MACHINE CHUCKS WORKED BY COMPRESSED AIR

MOST WORKMEN that are engaged in repetitive production are apt to grow fretful over the frequent resetting or adjustment of their machines. This is especially true if they have a real interest in volume of output.

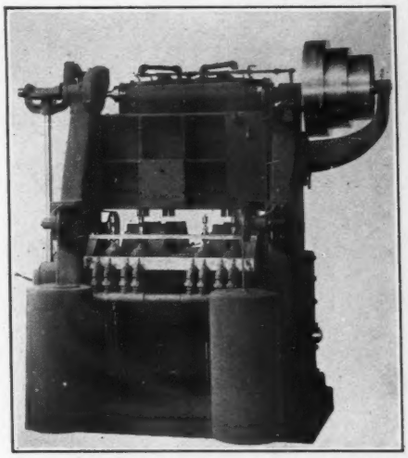
Recognizing this, the Foote-Burt Company, of Cleveland, O., has recently applied a novel adaptation of air drills, with marked success, in the operation of a 4-spindle boring mill furnished the Power Specialty Company of Dansville, N. Y. The boring machine is of a vertical, fixed-center type, and is employed in the preparation of super-heater radiator elements.

There are four chucks, one for each spindle, and each chuck holds one radiator element during the boring operation. The chucks are built with two movable jaws arranged so that they will slide on the chuck body. The jaws are shifted by means of a screw which is equipped with a right-hand thread, meshing with one jaw, and a left-hand thread, meshing with the other jaw; and in consequence of this arrangement the rotation of the screw in a single direction brings both jaws toward the center and clamps the work rigidly for boring.

Each chuck is provided with a No. 3-SC "Little David" air drill for opening and closing the jaws. This is made possible by the form of the operating screw, which is designed so that it projects both to the front and to the back of the chuck body—each end being squared. The front end is intended to receive a hand crank, if occasion require, while the rear end is connected to the associate air drill. Obviously, the rotation of the air drill can be made to function so as either to grip the work or to release it. The application of the air drills eliminates all manual adjustment, and therefore lightens the operative's task besides greatly increasing production. By the use of the air drills it is practicable to open simultaneously all four of the chucks for the insertion or the release of the work. Formerly, each chuck was opened separately.



Front of the machine. The 4-way air valve can be seen in the recess beneath the chucks.



Rear of the machine showing the four "Little David" drills and their associate air connections.

The air supply for the four drills is regulated by a 4-way valve which is placed at the front of the boring machine where it can be conveniently reached by the attendant. The four drills are piped to a manifold, thus insuring a constant and an ample supply of air.

SOME WONDERFUL OLD TUNNELS

THE following is a single item from a long paper by Lester S. Grant, Dean of the Colorado School of Mines, read before the Teknik Club of Denver.

In 1530, Agricola, a German mineralogist, recorded that the gold and silver mines of Schemnitz, Hungary, had then been worked for 800 years; the lead mines of Goslar, Germany, for 600 years; and the silver mines of Freiberg, Saxony, for 400 years. Subsequent working of these mines necessitated the driving of drainage tunnels of lengths as yet unequaled in the history of mining. The Tiefe Georg tunnel, in Saxony, driven between 1777 and 1799, is 34,529 feet long, with branches amounting to 25,319 feet more. This was driven entirely by hand to obtain a drainage depth of only 460 feet. The Joseph II. tunnel, at Schemnitz, was started in 1782 but not completed until 1878. It is 10¼ miles long. The Rothschönberger tunnel, at Freiberg, driven between 1844 and 1877, totals over 95,149 feet—the main tunnel being 42,662 feet. These tunnels were all driven by hand, using black powder.

Progress on the Hudson River Vehicular Tunnel

Despite Difficulties, This Great Engineering Job is Being Pushed Forward at a Very Promising Rate

By S. G. ROBERTS

ON THE 26th of October, just gone, pressure was applied on the first of the big shields by which the Hudson River Vehicular Tunnel is to be driven with the top of its twin tubes 69 feet below the surface of the water at mean high tide. This might properly be called the second step in the actual prosecution of this notable engineering undertaking: the first step consisting of the sinking of the two great land caissons in the path of the tunnel on the Manhattan side of the stream. Details about these caissons were given in the February issue, 1922, of this Magazine. One of these caissons was sunk at Spring Street and the other at Canal Street, New York City.

The Canal Street caisson is being used as the point of departure or base of operations for the driving of the first of the shields advancing westward from the Manhattan shore; and in order that we may properly present the activities which have followed since the 26th of October, it might be well to explain the part played by the caisson in question. Briefly, it has served for the digging of a rectangular excavation having a horizontal cross-section measuring 47x42 feet 4 inches and a depth of 63 feet below the curb where the cutting edge of the caisson was halted in a stratum of sand.

When the caisson settled to the desired depth, the working chamber was filled with concrete, and anchored thus, by a solid granolithic mass, the steel roof of the working chamber became a foundation or floor on which to erect and to assemble, within the caisson, the shield which was to pierce one of its walls in starting the journey riverward. Some of our illustrations depict various phases of the erection of the shield. First, a timber crib was constructed upon the working chamber roof so that the shield could be put together at just the right height to center it opposite a large, annular recess in the west wall of the caisson. This recess was formed by a steel ring closed at its outer end by heavy plating. Of course, the diaphram of this drum had to be removed when the shield was ready to be shoved forward and outward into the neighboring water-bearing soil.

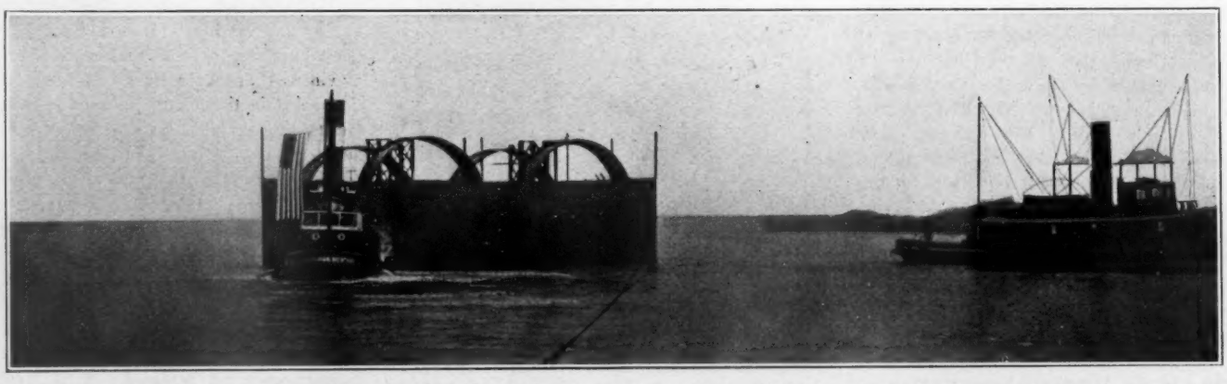
The shield was built by the Merchant Shipbuilding Company of Chester, Pa., and was assembled at that plant to make sure that all of its parts fitted to a nicety. Then it was taken down, and shipped piecemeal to New York for reassembling and permanent riveting. All the rivets on the outside of the shell of the shield were countersunk for the purpose of reducing friction between the shield and the earth through which it would have to pass. Some idea of the size of the shield can be gathered from the following dimensional details: total overall length, including hood, eighteen feet ten inches; outside diameter 32 feet 2 inches; thickness of skin plating 2¾ inches; and the total weight, fully equipped, is about 400 tons.

The shield has a hood which comes down to the one-half point at the front of the cylinder, and this is made of structural steel and projects 2½ feet beyond the cast-steel cutting edge. Inside, and near the tail of the shield, there are secured to one of the heavy annular frames 30 hydraulic jacks. These are disposed, at equidistant points, as indicated in one of the accompanying photographs. Each jack is capable of exerting a total thrust of 200 tons—a pressure of 5,000 pounds per square inch being maintained in the hydraulic line. The combined thrust of all of the jacks is, therefore, 6,000 tons.

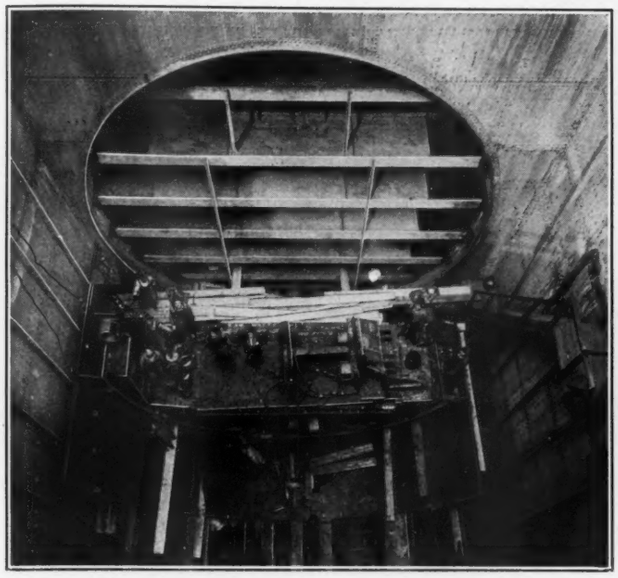
The jacks get their footing against the last of the assembled cast-iron rings which form the units of the tunnel shell, and when hydraulic pressure is exerted upon the pistons of the jacks the induced reaction shoves the shield forward—the cutting edge penetrating the soil in front of it. The shield is so dimensioned that the annular clearance between the inner surface of the tail and the outer surface of the tunnel rings is 1¼ inches. In operation, the tail of the shield overlaps two whole rings and twelve inches of the third ring last erected. Each ring is made up of 30 segments bolted together, and, measured longitudinally with the axis of the tunnel, a ring is 30 inches wide. Therefore, the overlap of the enveloping sleeve of the shield tail is six feet. The segments are placed in position for bolting by a pivoted and centrally hung counterweighted erector. The erector is rotated angularly by a horizontal shaft carrying a rack which engages a toothed wheel attached to the back side of the erector. The operating shaft is actuated by a hydraulic piston. The shield has twelve working pockets, through which the sand-hogs can get out and under the hood for the purpose of clearing away earth, rock, etc., in order to pass the spoils rearward into the shield for removal surfaceward.

When the Canal Street shield was ready for the application of pressure, towards the end of last October, the diaphram of the drum in the west wall of the caisson was removed piecemeal by oxy-acetylene torches, and progressively a breasting of timber was erected from the upper limits downward to prevent the outlying soil from caving in against the hood and the face of the shield. This breasting was kept in position by telescoping shores. For those who may not be aware of it, it should be mentioned that the breasting is maintained at varying distances before the shield during the different stages of the latter's progress. It is between this breasting and the front of the shield that the sang-hogs do their work.

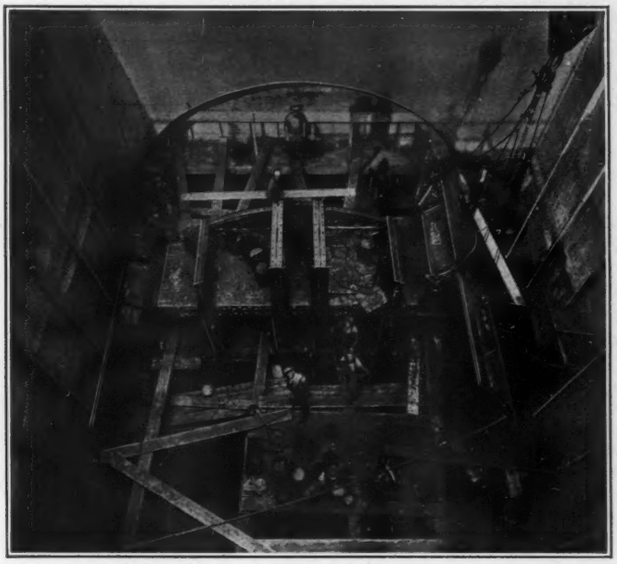
To the uninitiated, it is a source of wonderment how the shield for a subaqueous tunnel is advanced along any chosen path and directed to the right or left, straight ahead, or up and down. Briefly, the movement is controlled entirely by the way in which pressure is applied by the 30 jacks ranged circumferentially within the great cylinder. These jacks act like so many powerful fingers to divert the shield from or to hold it right ahead upon a predetermined course. That is to say, if more pressure is applied to the right half of the



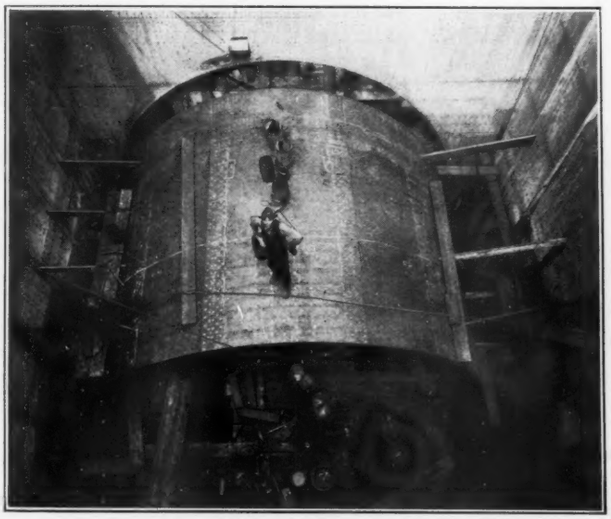
The offshore caisson which is to be sunk on the New York side of the river photographed just after it was launched from the yard of the Staten Island Shipbuilding Company.



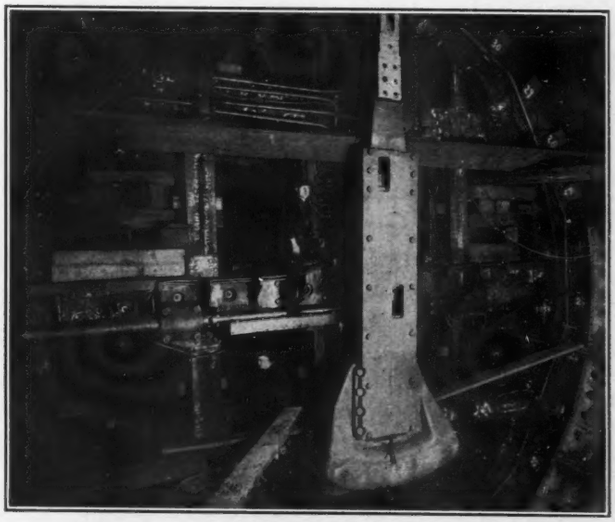
The first stage in assembling the shield inside the caisson sunk inshore at Canal Street.



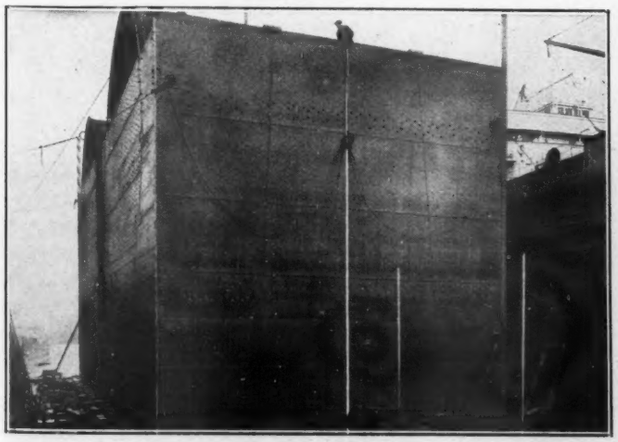
The shield with most of the internal structure and much of the steel shell assembled.



The shield well advanced, the shell finished, and the structure nearly ready to be put in service.

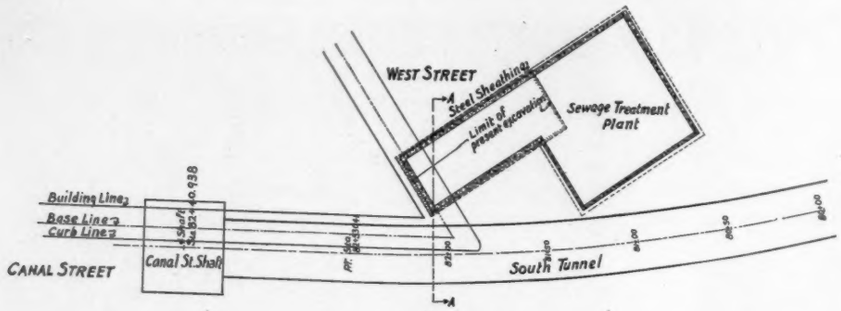


Inside the shield. The erector is the counterweighted, perpendicular arm at the right of the workmen.

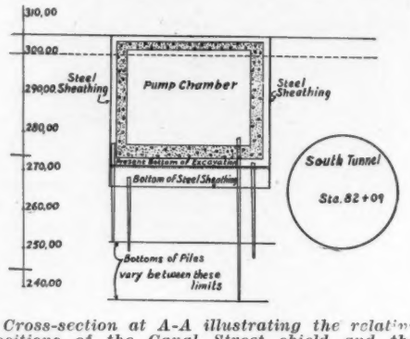


The offshore caisson just before launching. This will form the bottom of a ventilating shaft and be pierced by both of the tunnel tubes.

Inside the land caisson on the New Jersey side of the river. In sinking this structure the heavy timbers of some old cribwork were encountered.



Plan view of the line of advance of the Canal Street shield and its relation to the sewage treatment plant. It was at the point A-A that the blow-out occurred.



Cross-section at A-A illustrating the relative positions of the Canal Street shield and the near-by pump chamber.

shield, the structure will be forced forward to the left, and *vice versa*. Again, if the predominating pressure be exerted against the lower arc of the shield, the shield will tend to rise at the cutting edge, whereas the opposite will take place if the greater pressure is brought against the shield by the upper group of jacks.

Between October 26 and December 2, the Canal Street shield progressed far enough to assemble 27 rings and thus to construct 67½ feet of completed tunnel. On that date work was halted owing to leakage or the short circuiting of the compressed air supplied the interior of the shield. The air escaped through a comparatively thin wall of earth lying between the shield and a neighboring excavation for a sewage treatment plant. The released air blew 150 cubic yards of material into the near-by cofferdam; and the conditions compelled the shutting down of shield operations. An accompanying line drawing makes the situation plain. At section A-A the gap between the shield and the adjacent steel sheathing was only a little less than four feet.

As indicated by the sketch, a space was left between the concrete walls of the pump chamber and the outlying steel sheet piling—the purpose of this being to facilitate the lifting out of the sheathing after the completion of the pump-chamber job. The sheathing on the north side of the cofferdam will remain in place, and the gap between the cofferdam and the pump chamber wall has been filled with concrete. These provisions have prevented further leakage and effectually solved a difficulty that was not unforeseen. However, it held up the advance of the shield for about two weeks.

The Spring Street shield has been erected within the Spring Street caisson during the past month, and has begun its advance. The physical conditions at that point are such as to interpose no serious obstacles to reasonably steady progress.

On the 5th of December, there was launched at the yard of the Staten Island Shipbuilding Company the offshore caisson which will be sunk close to the pier-head line on the Manhattan side of the river. This caisson was christened by little Miss Ann H. Holland—the twelve-year-old daughter of Mr. Clifford M. Holland, chief engineer of the Tunnel Commission—who smashed a bottle of champagne against the towering steel structure just before it slid into the water. At the time of launching, the caisson measured from top to bottom 35 feet, had a length of 93 feet three inches, and a width of 37 feet three inches. It is now in drydock receiving a vertical addition of fifteen feet; and when this work is done the caisson will be towed up to its designed position and gradually sunk to a point directly athwart the descending path of the approaching shields. By the time the caisson is brought to rest upon the subaqueous rock it will have a maximum height of 108 feet 6½ inches. This will be effected by adding successive sections as the caisson settles progressively.

As the pictures of this caisson show, it will be pierced from side to side by two passages made up of a like number of steel cylinders just large enough for the shields to travel through—"threading the needle" is what the engineers call this exacting part of their task. The fact that the shields can be so nicely directed through the tractless mass of the Hudson River's primordial bed is the best proof of how accurately these structures can be shoved onward to their fixed destinations.

On the New Jersey side of the river, the first land caisson, that is the north one, has now been sunk to a depth of 30 feet, and has 37 feet more to go. In sinking this caisson some old cribbing has been encountered, and the character of this obstructing mass is clearly indicated by one of our illustrations. If the caisson could have been sunk 30 feet to one side this troublesome timber would have been avoided. As it is, the old piles, etc., have to be dug out and cut up into convenient lengths to facilitate their passage upward and outward through the air-locks.

The official party at the launching of the big twin-tube caisson. The youthful sponsor, Miss Ann H. Holland, is carrying a bouquet of roses.

During the current month the sinking of the south land caisson on the New Jersey shore will be started; and, according to the present schedule, shield tunneling from the neighboring north caisson will be begun about the middle of February. All piles have been put in place on the New Jersey side of the river for the support of the two offshore shafts or caissons. Because the twin tunnels will be somewhat farther apart than at the corresponding offshore position on the New York side of the Hudson, a separate caisson is needed here for the ventilating shaft of each tube. All told, 42 piles have been driven down a distance of 250 feet below the water's surface to ledge rock. These piles are formed of tubing which is cut off 100 feet below the surface of the river and filled with concrete.

The well-known firm of Booth & Flinn, Ltd., are the contractors for all of the subaqueous and under-river work of this engineering undertaking. The contract price for their part of the project is $19,331,723—an exceptional sum which plainly indicates the magnitude and the exacting nature of the job.

CLEAN AIR NEEDFUL TO MAKE MOVIE FILMS

JUST HOW important it is that the air in moving picture studios and laboratories be clean can be gathered from the fact that a speck of dust, passing in front of the camera, may be magnified to such a degree as to mar the face of the actor or otherwise blur or injure the photograph taken at the moment.

In order to obviate this, *Edison Monthly* tells us it is now the practice in modern studios to thoroughly "wash" the air, and this is done by means of reconditioning and filtering plants. One of the largest "film cities" in the world, which occupies a whole block and annex buildings adjacent, is provided with more than a mile of ventilating ducts and ten tons of heating coils, which latter are for the purpose of maintaining the air in the "dark room" and elsewhere at fixed temperatures.

Land 'planes, in order to get off the ground, must have a long stretch of open runway to give them a flying start. Now we are advised that so-called legs, operated by compressed air, have been designed that are said to lift airplanes quickly from the ground and to enable them to fly away at once by the propulsive force of their powerful propellers.

A Large Granite Quarrying and Crushing Operation

A Description of How a Difficult Material is Dealt With

By T. I. WESTON*

THE GRANITE quarries and the crushing operations of The Weston & Brooker Co., Cayce, S. C., may rightly be classed among the largest of their kind in the country. Not only are the workings exceptional in their location and in the territory that is served by them, but the granite is of an unusual quality and the methods employed in its production are uncommon.

The quarries are near Columbia, on the Seaboard Railway which offers southern and coastal connections. Being on the "fall line" at the termination of the foot-hills of the Piedmont section, 120 miles from the ocean, it is the nearest quarry to the Atlantic seaboard. This favorable location, together with its proximity to the coast, permits delivery of its product throughout a large territory which, normally, is embraced within the triangle formed by Columbia, S. C., Wilmington, N. C., and Jacksonville, Fla., and includes, besides, the area to the west for from 50 to 70 miles. When competing plants to the north and the west cannot supply the demands of the trade, or when specifications call for granite of a particularly high wearing quality, the Weston & Brooker product invades this outside territory, and has been shipped as far west as Asheville, N. C., and as far north as Richmond, Va.

It would not be practicable to produce and to market this hard and tough granite successfully if it were not for the advantageous railway facilities and for the large region to the east and the south which is substantially free from the competition of less expensive crushed stone. Of course, gravel does offer competition because it is much cheaper; but the granite in question —which has a high degree of toughness and has a French coefficient of about sixteen to seventeen—is in demand for paving and, likewise, finds a ready market for use in reinforced concrete because of its superior qualities.

Geologically, the stone is classed as a biotite-granite. It offers great resistance to drilling and to crushing, as well drills, for example, fitted with extra heavy tools and special bits, cannot average more than one foot of 6-inch hole per hour. The crushers must be of special construction throughout and be provided with manganese fittings.

Unlike many granites, this granite does not readily split, and, therefore, cannot be successfully worked for dimension stock. It breaks into comparatively compact pieces having rough fractured planes at approximately 60° to each other. This quality makes it peculiarly adaptable for use as crushed rock. Chemically, the granite is 72 per cent. silica, 14 per cent. alumina, with a little lime, potash, soda, etc., but it contains practically no flakes or streaks of mica. The specific gravity is about 2.66, and the weight per cubic foot solid is consequently 166 pounds. The granite is particularly beautiful and alive with endless gradations of colors. There are all shades of pink and, likewise, all shades of blue from light gray-blue through to blue of the darkest hue. The colors do not seem to be separated by a line of cleavage, but, instead, great blocks of them are shot in the solid ledges.

The quarry, which is a pit operation, is located on a flat, 40-acre area along the west bank of the Congaree River—the land having an average elevation of 35 feet above the normal water level. It is interesting to note that the floor of the quarry is about 160 feet below the bed of the river and something like 100 feet below sea level. The granite lies in a solid ledge under twelve or fifteen feet of overburden.

Roughly described, the quarry—700 and 800 feet of open pit—radiates fan-like from the crushing plant. This plant is on a down-grade spur 1,500 feet from the Columbia-Savannah line of the Seaboard Railway. The southwestern section of the quarry has a double face 800 feet long and is being operated to a depth of more than 200 feet while the northeastern end is 700 feet long with a 100-foot face on one side and a 40-foot face on the other.

Each of the workings just described is served by a radial traveling cableway with a tail tower just back of the primary crusher. The No. 1 cableway has a span of 865 feet and is about 75 feet above the surface level. The radial motion of the tower is imparted by a reversible motor, worm-driven drum, pulling in either direction upon steel rope carried to ground anchorage. The entire control is under the direction of one engineer whose cab is adjacent to the engine.

The No. 2 radial traveling cableway, in some features, is a radical departure from other methods heretofore in use. The traveling tower is simply a car built of steel and concrete which carries the engine in the middle and ballast at each end. The trucks that support the car are of 8-foot 6-inch gage; and the inside rail of the track upon which they travel is elevated about fifteen inches, thus throwing the center of gravity low and well back of the inside rail. The radial travel of the tower or car is induced by a direct-connected, 20-H.P. motor, driving a Fawcus worm-gear, which operates one pair of wheels. Its motion is therefore limited only by the length of the track.

Compressed air for the quarry is furnished by a motor-driven, Ingersoll-Rand compressor having a capacity of 1,200 cubic feet of free air per minute. The air is piped to all parts of the pits and serves to operate Keystone well drills for blasting, "Jackhamers" for pop shooting, and Ingersoll-Rand tripod drills for ledge blasting holes. The "Jackhamers" are of the DCR-13 and BCR-430 types, and are equipped with ⅞-inch hexagon heads for ⅞-inch hexagon steel. Bits with a 14° and 5° taper are employed on the "Jackhamer" steel while

Using the "Jackhamer" to drill block holes in large pieces of the rock.

*President, The Weston & Brooker Company.

A general view of one of the pits.

the tripod piston drills use Carr bits. All of the bits and the shanks are made on a No. 5 "Leyner" drill sharpener which has been in service for the past three years, giving excellent results the while.

Besides supplying motive air for the drilling operations, the compressor also supplies power to pneumatic tools of various kinds used for repair work, to forges, to drill sharpeners, to a derrick engine that handles machinery at the crushing plant, and to a furnace in the drier of the fine-screening system. The entire plant is electrified, and draws its current from the distributing system of the Columbia Railway Gas & Electric Company, a water-power development.

When preparing for blasting, 6-inch holes, from 110 to 140 feet deep, are drilled in double rows with the well drills. The holes nearest the face are placed 22 feet back and 22 feet apart while those in the second row, which are staggered with the holes in the front row, are fifteen feet back and 22 feet apart. The blasts are loaded with 4x8-inch, 60 per cent. DuPont nitroglycerine dynamite. The holes are loaded to within about 50 feet of the surface and are then tamped the rest of the way with screenings. Conditions permitting, small charges of dynamite are placed at intervals throughout the tamping. The shots are electrically wired as well as primed with Cordeau-Bickford fuses, thus assuring complete and instantaneous firing. Such blasts shoot down from 40,000 to 70,000 tons.

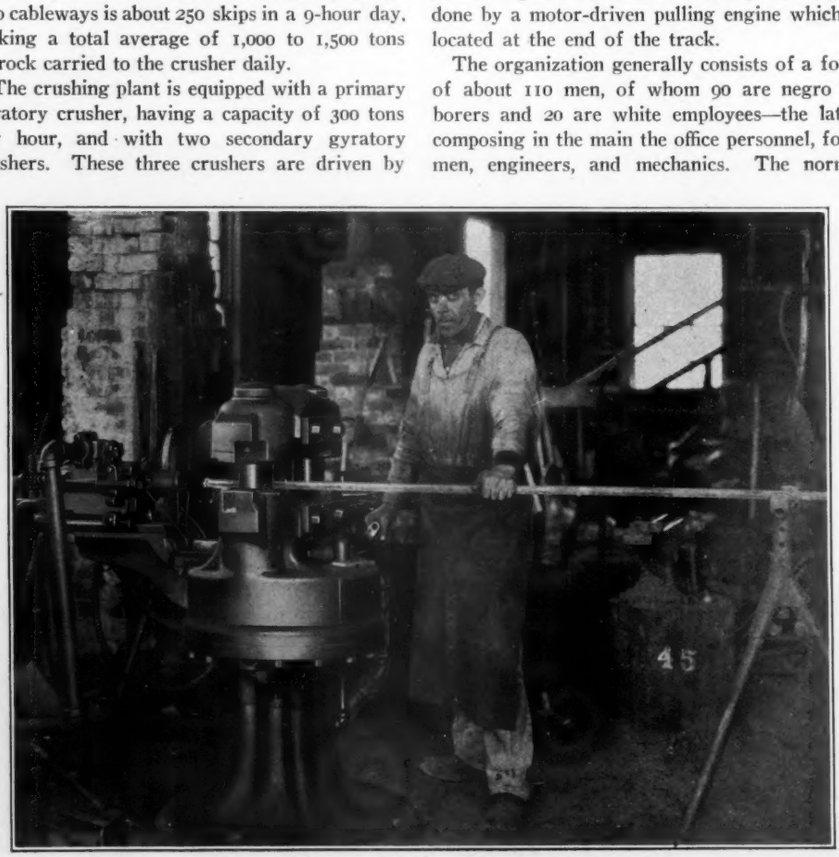
Steel skips, each of 6½-tons capacity, are placed along the face of the muck pile and are loaded by hand. The skips rest flat on the floor of the quarry with their open ends towards the muck pile, and the granite is loaded into them by barring and rolling. The use of steam shovels for this purpose has never been deemed practicable, and it is doubtful whether shovels of this kind could be operated and maintained at as low a cost as the hand-loading method practiced. The cableways handle the skips in rotation, and they hoist and convey them to the primary crusher in one operation. There they are dumped by the operator without placing or unhooking them. The combined capacity of the two cableways is about 250 skips in a 9-hour day, making a total average of 1,000 to 1,500 tons of rock carried to the crusher daily.

The crushing plant is equipped with a primary gyratory crusher, having a capacity of 300 tons per hour, and with two secondary gyratory crushers. These three crushers are driven by belt from a direct motor-driven jackshaft. A fourth crusher receives the rejections from the primary breaker by means of a specially constructed bucket elevator, and, in turn, delivers its rejects to one of the secondary crushers. This fourth machine is a new development in the crusher world, and has given results of a highly satisfactory character. The entire crushing plant is housed in concrete; and a fan system is provided to remove the dust.

The rejections from the secondary crushers are conveyed by a 30-inch belt-and-bucket elevator to a 5x24-foot Austin screen, which is located above the rock bins. Here the crushed stone is sized and distributed. For sixteen feet of the way this screen is provided with an 84-inch jacket having ¾-inch perforations. The material that drops through these openings is carried by a short belt conveyer to a combined drier and screen where the dust and the sand are separated from the stone. The ¾-inch product and the sand are marketed; but the dust, which is looked upon as waste, is collected by a water-spray suction system and then disposed of.

To facilitate loading the material that is ready for shipment there are three tracks at different points near the crushing plant. The main track passes directly under the rock bins, the second track is at the back and is used for side loading, while the third track, which runs between the crushing plant and the quarries, is devoted to riprap and jetty loading. The track capacity, without a switch, is sufficient to take care of fifteen cars loaded with crushed stone. In loading the cars, the necessary shifting is done by a motor-driven pulling engine which is located at the end of the track.

The organization generally consists of a force of about 110 men, of whom 90 are negro laborers and 20 are white employees—the latter composing in the main the office personnel, foremen, engineers, and mechanics. The normal



"Leyner" drill sharpener which has rendered excellent service ever since it was installed some years ago.

Skips of both cableways delivering rock at crusher dump.

operating day is a 9-hour one, and the operating week is of 5½ days. Experience has shown that closing down the plant at noon on Saturday facilitates repair work over the week-end, and, therefore, does not reduce the output.

Practically all employees are paid on the hour basis except the office force and the skip loaders. The last are paid by the ton. The time-clock system is used for all outside operatives; and the men on the job are paid a bonus based upon the tonnage produced each week. In apportioning this bonus, the workers are separated into three classes: Class No. 1 includes foremen, engineers, etc., and for them the bonus rate is twelve cents per 100 tons; Class No. 2 embraces skip loaders, drillers, and other semi-skilled workers, and their bonus is at the rate of six cents per 100 tons; while Class No. 3, which is made up of all common laborers, receives a bonus of three cents per 100 tons. In order, however, for any employee to be the recipient of a bonus on the week's production, he must not lose any time during the payroll week.

Although the bonus paid under this system amounts to from 5 per cent. to 7 per cent. of the payroll, in the opinion of the management the practice is good business. It stimulates the interest of every employee, from the lowest to the highest, in keeping up the tonnage, and it likewise encourages the operatives to make full time and to be prompt in reporting for work.

It may also be of interest to describe briefly the methods adopted by the company in handling accidents. For seven or eight years the concern has not carried any liability insurance, but is licensed by the insurance department of the State of South Carolina to provide insurance under a system of its own. Bulletins posted at various places about the workings and the plant, as well as other mediums of instruction, advise the employees of the conditions under which they are expected to work while in the service of the company. The men are not required to sign any agreements or releases before injury or to pay any fees in order to secure the benefits of the accident-insurance service. The printed notices constitute the company's pledge to its employees in case of accident; and this has been faithfully kept since its institution. The effect on the morale of the employees has been an excellent one, and has done much towards promoting cordial relations.

WORLD COTTON PRODUCTION AND CONSUMPTION

THE AVERAGE world production of cotton in 1921-1922 and 1922-1923 is 16,000,000 bales, and the present annual consumption is at the rate of 20,000,000 bales. This explains why the world stocks of the much-used staple were 5,000,000 bales less in August of 1922 than they were on the same date in 1921. This situation also makes it clear why existing stocks will diminish probably 3,000,000 bales more by the end of the current cotton year if consumption does not decrease in the meantime.

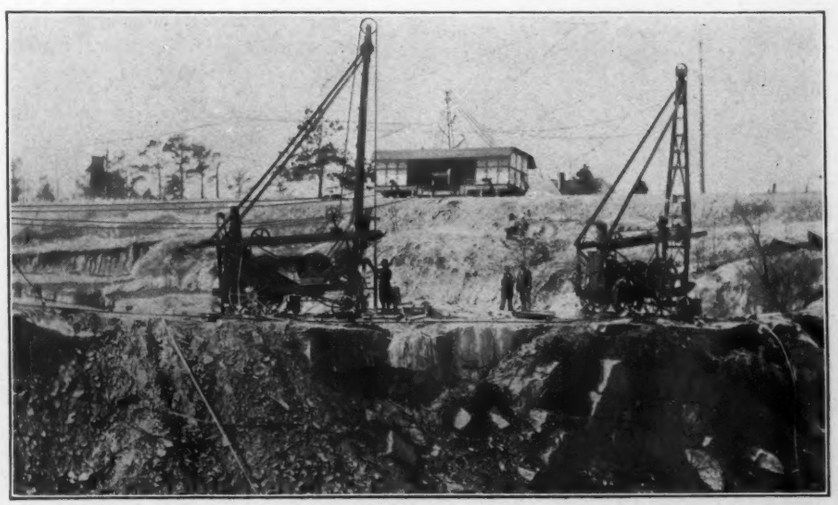
While it is somewhat reassuring to be told by the United States Government authorities that there is no likelihood of a shortage of cotton within the next twelvemonth, nevertheless the future supplies will depend on the rate of consumption and the size of the cotton crop in 1923-1924.

We are informed that up to about 1915 or 1916, the world was consuming nearly 21,000,000 bales and producing not much more with, of course, considerable yearly variations. For four or five years both production and consumption dropped, averaging about 19,000,000 bales. For the last eighteen months consumption has been mounting, and the world is now using more cotton than it produces—in other words, the staple is being consumed about 4,000,000 bales faster than it is being grown.

COMPRESSED AIR IN THE BREWERY

BEER is still very much alive in England; and a brewers' exhibition, recently held in London, was described as one of the largest and most comprehensive of its kind. The exhibits were numerous, and covered the entire industry. Refrigerating apparatus were shown in great variety. One of the most interesting items of the exhibit, says *Engineering*, was a pneumatic wort aerator and rouser comprising a small air compressor delivering air, at a pressure of twelve to fifteen pounds, through a purifier into a portable fitting placed in the bottom of the fermenting vessel. The object is to rouse and to agitate the yeast and to supply the necessary oxygen for its growth.

There is shortly to be inaugurated, according to the German Airship Company, a regular air service between Berlin and London. The flights will follow the Berlin-Hamburg-Bremen-Amsterdam route to Croydon Field, near London, connections being made at Hamburg with Copenhagen. The flying time between Berlin and London is estimated at 6½ hours. The passenger rates are to be a little more than those for first-class transportation on the combined railway and steamship lines between those two points.



Wagon-portable well drills used to drill holes in the very hard granite for blasting the entire face of the quarry.

The Economic Outlook in Europe Far from Promising

Such is the Finding of a Native of Northern Europe Who Has Wandered Widely in That Section of the World in Search of Profitable Employment

WHEN I RETURNED from Bolshevik Russia a couple of years ago, where I had been isolated from the outside world for many months, I was laboring under the illusion that the end of the war would clear up the atmosphere in Europe, and that a healthy business revival would follow. I had a mental picture of the activities to be in trade and industry; how they would prosper; and how rapidly the wounds caused by the war would heal. All this was very attractive because I thought I saw a place in the general scheme of affairs for a young man filled with ambition to land a job.

What a disillusionment! Of course, I found that there had been a post-war change in the course of European affairs, but hardly of an advantageous character. When I first returned to Copenhagen from Russia I rested a while, in order to recover from the effect of the privations I had undergone, and when I felt in good shape again I began to look around for a suitable position. But I quickly found that in spite of good connections I couldn't even land a job. Business was stagnant, and the few enterprises that were trying to wabble along had their existence made most unhappy by the continuation of the longshoremen's and seamen's strike.

While on this search for something to do I was able to observe and to learn much concerning the problems confronting the Danish businessman whose ship, instead of "coming in," seems to have run aground. At one time it was generally believed that Bolshevism would quickly run its course, and that Russian trade would then recover. Acting on this hypothesis, Danish merchants bought supplies with prodigality and paid high prices. They feverishly picked up anything they could lay their hands on; and it wasn't long before the spacious freeport of Copenhagen was so packed and jammed with goods and chattels that it seemed in fact to be too small. Much merchandise of a more or less perishable character was stored with no better protection than the canopy of the broad, blue sky.

Let it be said that Copenhagen's freeport enjoys an exceptionally favorable position in relation to the Russian market. Ordinarily, it is an economical port from the shipper's point of view, and its situation in close proximity to the Baltic coast and Russia makes it an ideal transshipping point for American cargoes. The distance, for example, between Copenhagen and Danzig is a stretch of approximately 265 sea miles as against 422 from Hamburg.

Nothing came out of the Russian speculations. In the meantime, the Germans bobbed up again in the world markets and, thanks to their depreciated currency and low wages, their competition was severe. Before long Danish industry and shipping were just about shut down. Take for instance a case that I know of, where a Danish company was able to get an order from the Russians for 250,000 spades. The concern ultimately had to buy these implements in Germany because the lowest Danish quotation was eight crowns apiece, while the Germans were offering them at two crowns apiece, f.o.b. a German port.

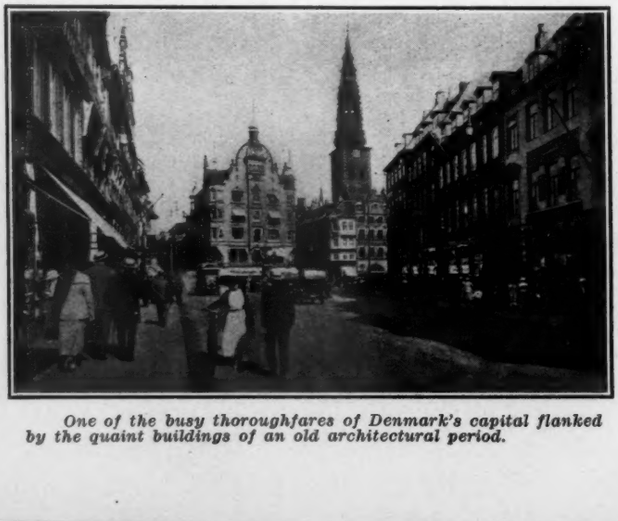
Hundreds of Danish steamers were laid up in the harbors because they could not afford to pay the high prices demanded for English coal, nor could they secure seamen to man their ships at a wage that would make competition with German steamers practicable. These latter steamers are supplied with very cheap coal of German origin, which, however, the Germans will sell only to their own people; and their seamen are very, very poorly paid. These unequal conditions temporarily gave the Germans an advantage which enabled them to grab routes heretofore served by Danish ships.

These various unfortunate circumstances tended to create in Denmark what was, relatively, a serious condition of unemployment. Out of a total population of 3,500,000 there were unemployed over 85,000, who received weekly unemployment doles from the state. This item of expenditure alone reached the astounding total of 1,500,000 crowns a week. It fell like a burden on the land, and could be met only by increasing the taxes.

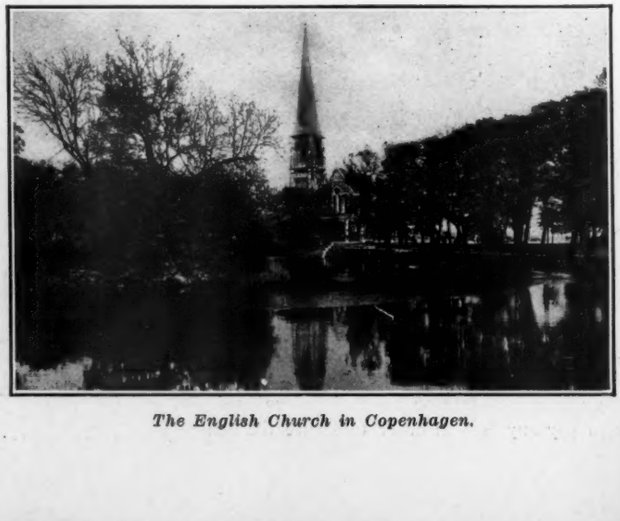
It was apparent that these conditions could not go on indefinitely. In a desperate endeavor to rescue Denmark's industry, trade, and shipping, it was deemed necessary to slash the wages which, during the war, had been driven up to unheard of heights. In order to bring expenses down to a level where a turnover could be made at a profit, all employees in offices, banks, etc., were notified on October 1, 1921, that their services would be dispensed with on January 1, 1922; and this was usually followed up by an announcement that if they cared to continue their jobs at a reduction of 50 per cent. they could do so. At that, many concerns were forced to reduce their staffs to about one-half, in addition to putting the wage cut in force. The people affected were compelled to accept these new conditions; but fortunately they were of a class endowed with enough horse sense to appreciate the justice of and the need for the readjustment.

Not so, however, with the workers and the sailors, whose wage agreements expired in March, 1922. Their reply to the proposed wage reduction was the inauguration of a strike. This strike was a long-drawn-out struggle that, for a time, assumed a menacing aspect with the ever-present threat of a general strike. The latter, happily, was averted largely because the entire remaining population was aggressively antagonistic towards the strikers, and carried the fight right into its own camp by voluntarily carrying on essential harbor and ship work under police protection. The government finally came to the assistance of the employers by declining further support, in the form of unemployment doles, to men ordinarily engaged in the srtiking trades. Then, in order to set a good example, the various townships cut the cost of electricity and gas, and the government reduced the railway passenger and freight rates.

Until the labor question is entirely adjusted and it is possible to dispose of the excess mer-



One of the busy thoroughfares of Denmark's capital flanked by the quaint buildings of an old architectural period.



The English Church in Copenhagen.

chandise purchased at peak prices, it looks as if much time will be lost and much money squandered. The Germans endeavored to take advantage of the situation by offering to purchase from the Danish merchants their inventories at about 25 per cent. of cost. Even though these goods have been stored for years in the freeport, the acceptance of this offer would be ruinous, and many large concerns and banks would be badly shaken even if they did not go to smash.

The Danish merchant marine, like many others, earned scandalous profits during the war and, consequently, many unsound and undercapitalized ventures sprang up right and left. With few exceptions, however, these profits have been dissipated either through the ill-advised payment of large dividends or through the embarking upon a program of ship building at excessive costs. In fact, the war earnings have been considerably offset by subsequent losses; and now the majority of the large shipping companies again find themselves absolutely in the hands of their bankers and many of the small "war babies" have been "spurlos versenkt" amidst the lamentations of the unfortunate shareholders. Others have been swallowed up leisurely by the larger and stronger operators. The present-day stock exchange quotations present a doleful picture of the shrinkage that has taken place in the large fortunes of 1916 and 1917. Now we see the shares of the substantial shipping lines selling at about 150 per cent. of par as against the quotations of 3,000 per cent. in 1916 and 1917. Shares in large business houses are quoted at 10 to 11 per cent., instead of at the war-time figure of 400 per cent., and industrial securities may be picked up at from 10 to 12 per cent. of their par value as against the recent quotations of 500 per cent.

The main hope for betterment of business conditions in Denmark lies either in an advance in the exchange value, or at least a stabilization of the value of the German mark, and in the resumption of an unrestricted and safe trade with Russia. In the long run Denmark cannot exist solely on its exports to England of butter and pork.

When I was sojourning in Germany recently, I was entirely unsuccessful in my efforts to land a job because it developed that it is practically impossible for a foreigner to be even taken on as an office apprentice. (It has long been a custom in European continental countries for a young man to start his business career by entering an office as a volunteer. This virtually corresponds to an apprenticeship. The volunteer ordinarily receives no salary, and it is not unusual for a young man's parents to even pay the boy's employer a nominal sum equal to about ten cents a week. The apprenticeship may last anywhere from three months to two years; but after a few months the apprentice is sometimes paid the equivalent of from 50 cents to $2.50 a week). Once the local authorities, the police, observe that a foreigner is on the lookout for employment the right of residence is withdrawn, and the person affected must thereupon return to his own country.

The Germans are employing none but their own people and this, together with the low exchange valuation of their currency, enables them to exclude outside competition. Their factories and industries are working under high pressure and, for the present, unemployment does not have to be dealt with. The Germans are very uneasy over the exchange situation in respect to the mark, and are particularly apprehensive of a sudden rise in the value of their money. Should that occur their scheme of world competition is done for. They will be face to face with an unemployment situation of considerable proportions, and their population, still more or less unnerved by the rigors of war, may succumb to the enticements of the radicals and create a second Russia in their country.

City Hall Plaza in Copenhagen, the "Athens of the North."

A local financial paper, "Bank," recently published an article that contained some pertinent remarks on German economics and on the actual losses suffered by that country on account of the continued fluctuation of the currency:

> "It is quite impossible to estimate the total of the damages accruing in Germany through the dissipation of their own efforts and the overpayment to foreigners of the services they render. The specific data published from time to time in the newspapers in regard to the disparities prevailing in the German export prices is so astounding that one must draw certain conclusions from the situation. (At times it is said that Germans have quoted their machinery at a price representing 75 per cent. of the world market price.) When one takes into consideration that Germany is selling too cheaply by one-third and buying too dearly by one-fifth, and then estimates the annual imports and exports, including those not encompassed by the statistics, at but 6,000,000,000 gold marks each, it is evident that through the fluctuation in foreign exchange alone, an annual capital loss of 3,200,000,000 marks is incurred in foreign trade. In other words the depreciation in currency is costing Germany far more than the reparations bill."

Germany is working feverishly, but the business conditions in that country on every hand are unhealthy. They are artificially stimulated and the momentary prosperity is based exclusively on profits of a speculative nature. One must be prepared to expect a sudden collapse at any moment.

A prominent United States oil company is shortly to erect a large warehouse for the storage of petroleum, together with associate facilities, at Harbin, China. This is another evidence of the importance of Harbin as a distributing center in the Far East.

The inner roadstead and the freeport of Copenhagen, Denmark.

The Simplon Tunnel Finally Completed as Originally Planned

By A. M. HOFFMANN

WITH THE recent opening for traffic of the second bore of the Simplon Tunnel there has been brought to successful conclusion an engineering project that was begun more than 24 years ago and which, at the time, was of unprecedented magnitude. As a matter of fact, so uncertain was the outcome that the countries interested deliberated over two years before approving the plans as then submitted.

From 1857 on various schemes were proposed for tunneling the famous Simplon Pass for the purpose of shortening the distance by rail between northeastern France and Italy and the time in transit between England and Italy. Two of these projects planned to scale the Alps, while as many as 28 suggested tunnels. But it was not until 1893 that the Jura-Simplon Railway Company entered into a contract with Brandt, Brandau & Company of Winterthur, Switzerland, for the construction of a low-level tunnel, with easy gradients, to connect Brieg, Switzerland, with Iselle, on the Italian side of the Simplon Pass. The plans for this tunnel were finally approved by a commission of noted engineers from Italy, Austria, and Great Britain; and on November 25, 1895, a treaty was signed by the Swiss and Italian governments permitting the Jura-Simplon Railway Company to begin operations.

The 1893 plans called for two parallel, single-track tunnels, 12.4 miles long, and 56 feet from center to center. The system of twin tunnels was adopted in order to avoid the rise or "creep" of the roadbed due to the great pressure that would be exerted by the towering mountains on the side walls of a single larger passageway, which, in turn, would tend to force up the floor. Work on the first of the tubes was commenced at the Swiss end on November 22, 1898, and a month later—to be exact, on December 21, operations were begun at Iselle. From then on work at the two headings was pushed uninterruptedly and was brought to a conclusion on February 24, 1905—three-quarters of a year later than the date specified in the contract. This tube was not ready for service until January 25, 1906.

More serious difficulties were encountered in driving this tunnel through the Alps than in putting through any engineering task of a kindred nature. The undertaking reached its greatest depth, 7,005 feet, under Mt. Leone, which rises 11,684 feet above sea level. This depth is said to be the lowest one ever reached by man in tunnel building. In order not to release the latent pressure of the mountains in advancing the headings, two things were absolutely necessary: rapid work and prompt filling in of excess spaces caused by blasting. So great was this crushing force at times that the roof and the sides could be held in place only by steel I-beams and by ramming quickly setting concrete into the interstices. Sections of the tunnel, where the pressure was greatest, are said to have cost as much as $1,620 per linear foot as against an average cost of $239.40 per linear foot.

One factor that greatly hampered progress was the large amount of water that had to be dealt with. Numerous springs were encountered, and as many as 17,000 gallons of cold water per minute flowed into the tunnel. When nearing the center of the bore, wells of hot water were struck, and one of these alone poured forth something like 1,400 gallons a minute at a temperature of 116° F. This problem of high temperature at first threatened to prevent further advance; but by bringing both cold water and cold air into the tunnel in sufficient volumes the temperature was reduced to a point which permitted work to be continued.

The rock through which the tube was driven consisted principally of gneiss, with occasional beds of slate, granite, and marble; and the drilling at both headings was done by rotary hydraulic drills. The average daily rate of progress was 13.69 feet, but under favorable conditions a maximum of 21 feet was attained at the Swiss end. When penetrating hard rock, the cycle of operations was as follows:

Bringing up and adjusting drills	1/3 hour
Drilling	1¾ to 2½ hours
Charging and firing	¼ hour
Mucking	2 hours

The splendid progress that was made, despite the many difficulties encountered in boring the first of the tubes under the Simplon Pass, may be attributed to a working organization of exceptional efficiency, which made it possible to keep 648 men and 29 horses employed at the Swiss end of the tunnel and 496 men and 16 horses engaged on the Italian side. The total cost of the undertaking amounted to $15,700,000.

Parallel with the original tunnel there was run, simultaneously, a small gallery, which was separated from the main bore, center to center, by a distance of 56 feet. This gallery, which was connected with the railroad tunnel by a series of oblique transverse passages, served to facilitate constructional work, and was used to furnish air to lower the temperature, to carry away seepage, etc. Furthermore, it afforded a refuge for the workmen, and a convenient place to house equipment, tools, and stores. Upon the completion of the first half of the project, this gallery was enlarged midway for a length of 577 yards; provided with tracks; and joined by means of switches with the main tube so that trains, entering from opposite ends, might be able to pass each other inside the tunnel. The gallery has been increased in size to correspond with the main tunnel, and now forms the second bore of the Simplon Tunnel, giving a two-way freight and passenger service. Competent engineers do not hesitate to say that but for the existence of this paralleling gallery the tunnel, as planned back in the early "nineties," could never have been carried to a successful conclusion.

So much for the original undertaking as completed January 25, 1906. Now let us describe the work recently finished, by which the route under the Alps was amplified so as to put twin tunnels at the disposal of the railway. The second bore was begun on the Swiss side in December of 1912; and in April, the year following, work was commenced at the Italian end. Though nine years elapsed before the two headings met in December of 1921, the actual time required to drive the tunnel was no doubt less than that consumed

A great water-power plant which generates the electric energy by which trains are run through the Simplon Tunnel, a distance of 12.4 miles between portals.

An electrically drawn freight train at the Swiss end of the Simplon Tunnel. The old run over the Pass was a journey of 42 miles and involved a climb of 4,200 feet.

© E. Gallaway, New York

The twin tunnels, through the Alps, which connect Switzerland with Italy, and obviate the high climb over the old Simplon Pass.

in the case of the first one. By December, 1914, 43.6 per cent. of the entire bore had been completed, but from that time on, and until the armistice was signed, the European War greatly hampered progress.

Prior to the outbreak of hostilities, between 1,000 and 1,100 men were employed in each drift, but this number was finally reduced to less than 600 on a side whenever work could be prosecuted. From August 22, 1914, to February 7, 1916, operations ceased on the northern end by order of the Swiss General Staff. Italy, however, did not stop tunneling even after her entry into the war, on May 23, 1915, although mobilization reduced the force to such an extent that headway was slowed down materially. Only old men and boys not of military age were left to push the job onward. In 1916, the daily rate of advance made by the Swiss, working three 8-hour shifts, was from nineteen to twenty feet; and the Italians, who were able to operate but two shifts, barely accomplished fifteen feet per diem.

It is not our intention here to tell the whole story of the way in which construction was held up: it is enough for us to know that the section of the tunnel through Switzerland, having a length of 30,000 feet, was finished in May of 1918, and that there were then still about 7,500 feet to be bored through Italian soil. That part of the Simplon Tunnel which lies in Italy is more than 35,000 feet long. In June of 1919, concluding operations were taken in hand on the south side, and on December 4, 1921, the keystone of the last arch was placed. Right here it might be well to state that the Italian and the Swiss governments bought up the rights of the Jura-Simplon Railway Company before the completion of the first passageway, which they finished. The second tunnel was built in its entirety by the two countries in question.

The natural difficulties encountered in driving the second bore were similar to those met with when first piercing the Alps from Brieg to Iselle, and the experience then gained enabled the engineers to readily cope with them. Conditions, however, were somewhat aggravated owing to the nearness of the finished tunnel, the walls of which were damaged in places by concussion due to blasting. Steel reinforcing was put in at points that were considered dangerous, and the spaces back of this were filled with liquid cement forced in by the aid of compressed air.

Prior to the war, and while work was in full swing, a battery averaging 40 air drills was operated in each drift. On the Swiss side, where the pneumatic tools made splendid progress, most of the drilling was through hard gneiss; but at the other end the ground was more yielding, and in some places consisted of limestone or soft, micaceous material which offered a poor hold for the bite of the drill. In consequence, a few short stretches had to be excavated by hand. All hauling within the tunnel was done by storage battery and compressed air locomotives. Both tunnels were lined with masonry throughout.

The Simplon Tunnel is now completely equipped with double tracks for a two-way railway service, which has greatly speeded up traffic. It is not only the longest freight and passenger tunnel in the world but it is also the lowest of the various Alpine tunnels. By reason of its easy gradient, about 37 feet to the mile, it can be negotiated readily by heavily loaded cars and, therefore, offers the best facilities for the handling of freight in that region.

The run through the tunnel is made in about twenty minutes. Like most Swiss railroads, the division is electrified, and draws its current from hydro-electric power plants. The Simplon Tunnel was originally planned for steam traction, but this proved to be quite impracticable. In conclusion, let us say that the short cut afforded by this route through the Alps, which lies between the St. Gothard and the Mont Cenis tunnels, especially benefits French Switzerland and northeastern Italy. It has lessened the time in transit between Paris and Milan a matter of from 3½ to five hours, and it has shortened the trip from London to Brindisi about 180 miles.

Almost 15,000 cities and communities in the United States enjoy the benefits of electricity for lighting and power.

SPRAYING MORTAR IN MINES BY COMPRESSED AIR

THE CEMENT gun, for the application of cement mortar by means of compressed air, offers great possibilities for the lining of passageways, etc., in mines. By protecting the roof and the walls of such passages from weathering with a thin coat of concrete it is possible that the expense of timbering, which is a heavy one, may in many cases be avoided. The cement gun would also seem to lend itself readily to the fireproofing of timbering, board stoppings, and to the erection of fire walls in places that are more or less inaccessible, inasmuch as compressed air is capable of throwing the mortar, so to speak, over considerable distances.

BIG COPPER DEVELOPMENT IN CANADA

THE BIRD Lake district of Manitoba, Canada, so we are informed by the Iron & Steel Division of the United States Department of Commerce, is estimated by mining engineers to contain millions of tons of high-grade copper ore, assaying at from 20 to 27 per cent. copper, with a valuation per ton placed at $81.13. It is said that something like $10,000,000 capital will be necessary to develop the territory. The Devlin Mining & Development Company of Winnipeg is preparing to commence exploratory drilling. At the Anderson mines, where claims covering about 400 acres have been located, the vein has been opened up for a distance of 465 feet, with 35-foot tunnels. The ore body consists of from seven to fifteen feet of solid chalcopyrite, 34½ per cent. copper, with intrusions of bornite, 55 per cent. copper.

OPENING UP AFRICA

IF RAILWAY projects in Central and South Africa now under consideration are carried out, the Belgian Kongo, Rhodesia, and Central South Africa will be linked within five or six years with the Atlantic coast by three new lines, opening up virgin territory.

The three roads in question include the connection of the Katanga and the Kasia districts of the Belgian Kongo with the mouth of the Kongo River; the completion of the Benguela Railway; and the construction of a new line between Walvis Bay and Mafeking. The Belgian government expects to commence operations on the Kasia road early this year. One-third of the Benguela Railway has been built, and is to be completed as soon as additional capital, which it is said is being sought in the United States, can be secured. When finished, this line will provide a direct route from the Katanga copper field to Lobito Bay, a distance of 1,160 miles.

The Walvis Bay project will serve not only southwest Africa but southern Rhodesia and the Transvaal; and it will shorten the run to Mafeking about 1,000 miles. It will reduce the time in transit from the Transvaal to Europe and to the United States 72 hours. The government of South Africa has likewise appropriated £600,000 for harbor works at Walvis Bay; and it is understood that a large refrigerating plant is contemplated there.

Status of Work on the Delaware River Bridge

Caissons Sunk and Foundations Placed for the Two Main Piers

By J. HANLEY WILKERS and A. S. TAYLOR

THE DELAWARE River Bridge, in its broad engineering aspects, has been dealt with at some length in a previous issue of the Magazine. Since that article appeared last March considerable work has been done towards furthering the actual construction of the great undertaking, and it is therefore deemed well worth while to describe the outstanding features of the progress made.

As previously mentioned, the bridge will have a span of 1,750 feet between the centers of the two main supporting towers. The steel work of these towers will rest upon piers carried down to rock, and in each case this foundation must be placed offshore and at a considerable depth below the surface of the tideway. To meet these requirements it has been needful to sink two caissons of exceptional magnitude and to combat the while hampering conditions which have compelled the engineers to draw without stint upon their resourcefulness. We are fortunate in being able to tell just how the experts overcame every obstacle successfully and with very commendable dispatch.

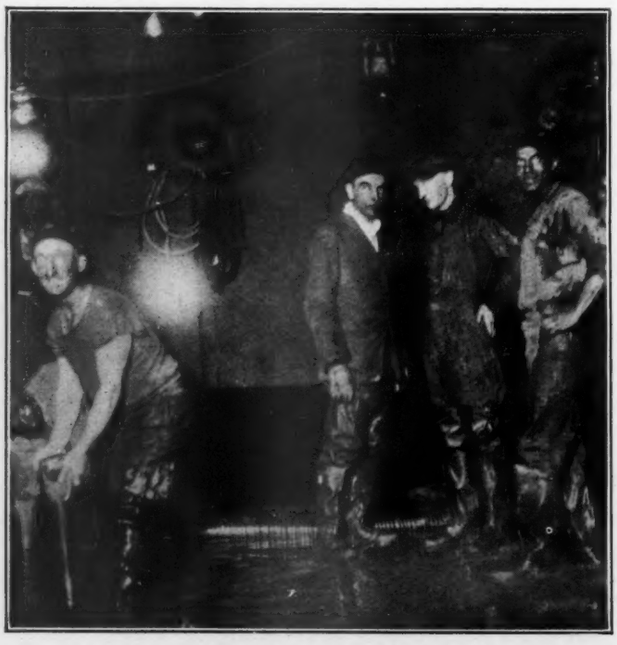
The caissons, constructed of steel and wood, were built by the New York Shipbuilding Corporation at its plant in Camden, N. J., and longitudinally they have the same dimensions, differing only in height. To be exact, these caissons are externally 70 feet wide and 143 feet long. The caisson sunk on the Philadelphia side of the river measures vertically 65 feet, while the caisson on the Camden side of the Delaware is 89 feet from top to bottom because the latter structure had to settle considerably deeper in order to reach the prescribed rock foundation. As a matter of fact, these caissons are of unprecedented size and designed with due regard to the special circumstances surrounding the sites for the piers of the two towers.

The caissons were taken in hand by the builders in the order in which they would be needed, that is to say, Caisson A for the Philadelphia pier was started the latter part of January, 1922, and was launched on April 24, following. Caisson B, for the Camden pier, was then begun and was put overboard on July 18. The main framing and the internal bracing of half of each caisson above the working chambers are of heavy steel, while the interior bracing for the upper half is made up in the main of 12x12-inch timbers. The supporting wall timbers, which were run horizontally, are of 12x12-inch pine. The walls were then sheathed diagonally with 3x12-inch planking; and to make doubly sure of water-tightness, a second course of sheathing, of the same dimensions, was laid vertically as a final finish. The area lying within the contours of the steel cutting edges and below the steel roof of the working space was formed into five working chambers by the interposition of four pendant bulkheads, suspended from the steel roof just mentioned. Each bulkhead was pierced by two openings, which provided a means of communication between adjacent compartments of the working chamber.

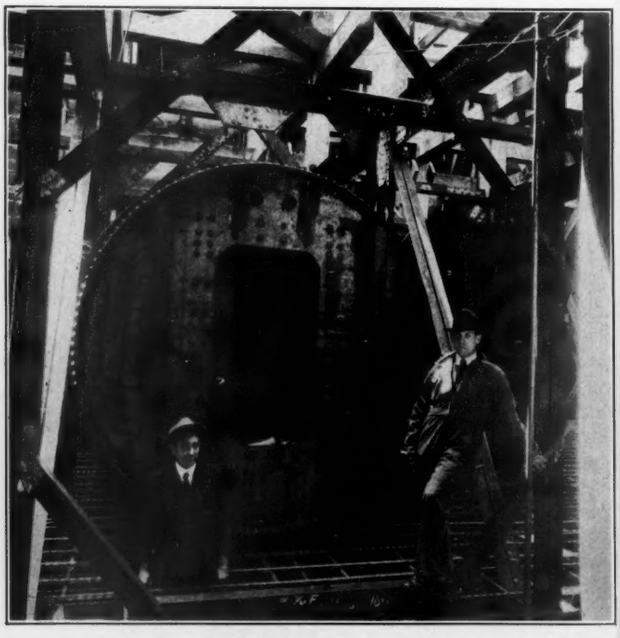
The working chambers are 8½ feet in height from the cutting edge up to the under side of the steel roof. The upper 15¼ feet of each caisson was made removable, so that it could be cleared away above water after it had served its purpose during the building of the foundation and the emplacement of the superposed stonework. Each pneumatic compartment was provided with two muck locks, supported by annular steel shafting—the latter providing hoistways or passages three feet in diameter.

To safeguard the operatives during the sinking of the two caissons, provision was made for the security or the escape of the sand-hogs should the air service fail or either caisson settle suddenly by its own dead weight when encountering a stratum of decidedly yielding soil. A staircase was built which extended from the top deck of each caisson down to the platform on a level with the doors of the two big compression or decompression locks located within each caisson a few feet above the roof of the working chambers.

The stair-well was erected in successive sections as the caisson settled. The well was formed by rectilinear walls, ranging in thickness from five to three feet, and care was taken to see to it that this water-tight shaft was never less than five feet above the surface of the river. Had water entered either caisson unexpectedly and in a menacing volume, it could not have flooded the stair-well so as to interfere with the escape of the sand-hogs coming up from below. The recompression or decompression locks, each of which had a diameter of eight feet and a length of fifteen feet, constituted intermediate links between the stair-well and a longitudinal passageway, three feet wide and seven feet high, built above the working chamber roof and connected with each of the working compartments. It might be mentioned here that each caisson had a 4-



Down on the river bed of the Delaware within one of the several compressed air filled compartments of the caisson.

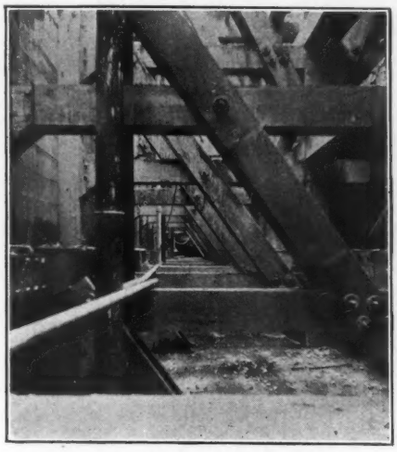


One of the two big air-locks in Caisson A placed deep down in the structure and just above the pressure working chamber.

foot vertical shaft equipped with an elevator hoist and air-lock, which made it possible for the workmen to ascend and descend more rapidly to their jobs in the pressure chamber than they could have done had they been obliged always to go up and down by way of the stairs.

As will be realized, the horizontal passage was, in effect, a magnified development of the T-lock principle, and provided a place of security should a blow-out have occurred. It made it entirely practicable for all of the sand-hogs to quickly leave their different working chambers, to mount to a platform nearly twelve feet above the cutting edge, and to enter the emergency chamber or passageway from which they could reach rather deliberately the decompression locks. Again, they could have followed a similar course had the air service broken down, and plenty of time would have been at their disposal to gain admission to the recompression locks before incoming water could have overtaken them.

The sinking of the caissons was done by the Keystone State Construction Company of Pennsylvania, collaborating with the Holbrook Cabot & Rollins Corporation of New York. Let us describe in their proper order the sinking of Caisson A and Caisson B. Caisson A was towed to its assigned position on the Philadelphia side of the river and moored directly above the site for the pier foundation at that point. Previously, the river-bed had been dredged out to Elevation — 42 feet. At the start, the caisson had a draft of fourteen feet, and it was necessary to sink it to the bottom of the excavation to bring it in contact with the mud, and from there on to cause it to settle until it arrived at a depth of 58.12 feet below mean low water. The compressed air was turned into the working chambers on May 25, and the caisson was brought to rest on the underlying rock on June 20, when sealing operations were begun. This latter work was completed on the 1st of July. The rapidity with which the sinking was accomplished established a record, and at first blush gives no idea of some of the things that had to be done to deal with the difficulties that were encountered.



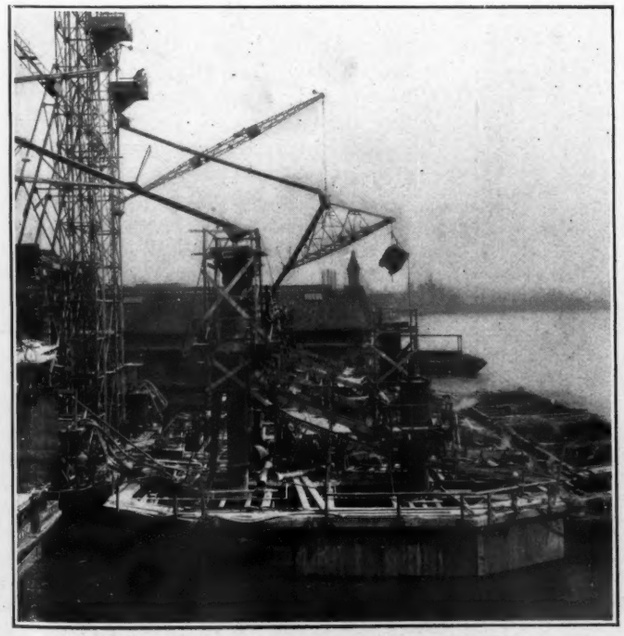
An interior view of Caisson "A."

In getting Caisson A down to rock bottom it was necessary to excavate by way of the working chambers a total of 7,300 cubic yards of earth. When the rock was first struck it was found that the ledge sloped at a steep angle, and this imposed the removal of soil a number of feet deeper at one end of the caisson than at the other. As a matter of fact, 150 cubic yards of the rock had to be drilled with pneumatic tools and blasted. For this purpose a battery of fifteen "Jackhamer" drills was employed, and with them holes ranging in depth from three to sixteen feet were made. These were spaced from 2½ to five feet apart, and were then charged with 40 per cent. dynamite for blasting. The problem for the engineers was to obtain support for all four edges of the caisson while holding the structure in a vertical position against the sharply dipping ledge. This was achieved in the manner indicated by one of the accompanying illustrations.

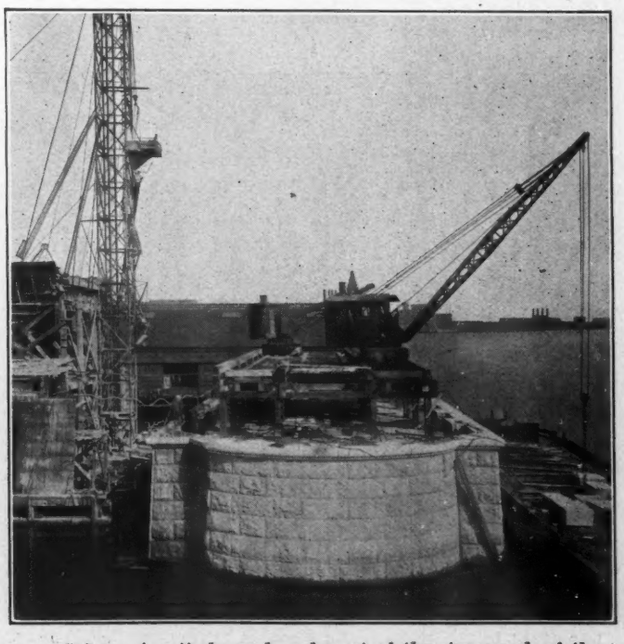
Starting at the cutting edge not in contact with the ledge, a section of concrete was cast immediately below the cutting edge, in a suitable form, while the air pressure in the working chamber held the outlying mud and water at bay. When the first section of concrete had set, the mud beneath it was dug away and a second and contiguous section was similarly placed. Thus, progressively, a curtain wall was built downward until union was made with the ledge after care was taken to insure a proper bond between the concrete and the supporting rock. As can be seen, this foundation, which held the caisson on an even keel, was built in the reverse order to that usually followed in the erection of a foundation and was, therefore, decidedly novel.

With the foregoing work finished, the sealing of the compartments of the working chamber followed. This was effected by utilizing the muck locks, which became spouts or chutes down which the concrete could be delivered; and this material was spread by the sand-hogs as long as it was possible for them to do so within the diminishing space. It should be understood, of course, that the dead weight needful to insure the progressive sinking of the caisson was obtained by depositing concrete within the structure above the steel roof of the working chamber, and thus, at a comparatively early stage in the undertaking, the refuge passage or "tunnel," as it was familiarly known, was completely encased in a granolithic mass. This passage, after the working chamber was filled with concrete, was likewise sealed—the concrete being poured into it through a number of 1-foot down-spouts. None of this material was spread by hand but was allowed to distribute itself by the action of gravity.

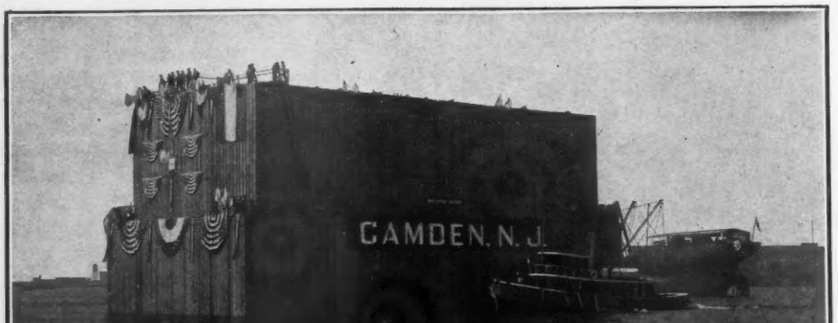
The compressed air plant installed for the sinking of Caisson A was composed of six compressors. This equipment was later moved to Camden for the sinking of Caisson B. The machines had a total capacity of 5,128 cubic feet of free air per minute. Owing to the fact that the pressure of the air in the working



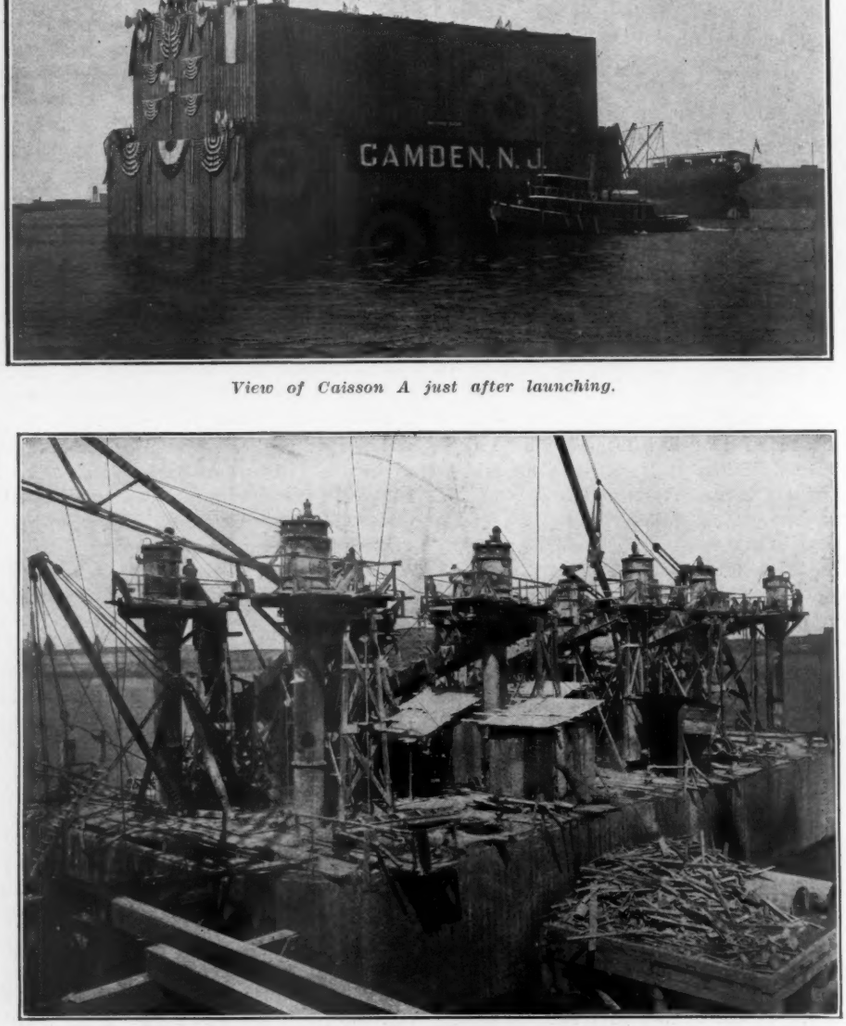
Caisson A on the Philadelphia side of the river in its final position and resting upon rock way below the water bed.



Caisson A entirely sunk and most of the stone-work of the superposed pier in place.



View of Caisson A just after launching.



A close view of one of the caissons during sinking. The air-locks of the mucking shafts were placed high above the top of the caisson to insure an ample slope for the chutes carrying muck to the scows.

One stage in the sinking of Caisson A. Note the large number of air-locks. It was up through these locks and the connecting shafts that most of the muck was raised from the working chamber.

compartments was comparatively low even at maximum depth, it was not found necessary to provide any special equipment to cool the air to improve conditions for the sand-hogs. The temperature in the chambers ranged from 90 to 95° F. The air required for the operation of the pneumatic rock drills was supplied at a pressure of 100 pounds. All of the compressors were steam driven and drew their energy from a battery of six 100-H.P. locomotive boilers, which furnished the steam at a pressure of 125 pounds. The feed water was handled by a 6-inch Cameron steam pump. The discharge from the compressors was led to four air receivers, three low-pressure reservoirs and one a combined high-and-low-pressure tank. From the receivers the air was piped to the end of the dock on which the power plant was located and thence to different parts of the caisson. Inasmuch as the compressors were called upon to furnish air continuously throughout 24 hours every day in the week, only three or four of the machines were run at a time—the other compressors being held in reserve. It will probably be of interest to describe at this point the manner in which the air pipe lines were run.

One 6-inch and one 4-inch pipe, on each side of the wharf, carried the air to the river end of the dock. A 3-inch line was run independently down the center of the pier to provide motive air for the pneumatic tools. The disposition of air lines on either side of the wharf was a precautionary measure against any possible damage by boats or scows tied up alongside the dock. The Bridge Commission did not want to run any risk that might invite cutting off the compressed air from the men working within the caisson. At the time this installation was made the entire pier was not under the control of the bridge authorities, and it was still available for use by local shipping.

At each side of the wharf there was a control box, made up of a number of valves, with an operator on duty all the while to regulate the pressure needed in the subdivisions of the working chamber, The attendant was instructed what to do by means of a telephone connecting with the office on the dock; and the office maintained telephonic communication with each compartment and other essential points within the caisson. Knock signals on the shafts also served to transmit messages, so that audible intercourse could have been established between those inside and those outside of the caisson had the telephone system broken down.

Had all of the compressors failed because of lack of motive power, or for any other reason, the workmen would have been protected by clapper valves, built on the check-valve principle. These valves would have served to hold the air in the pressure spaces long enough to allow the men to come to the surface. All told, something like 400 sand-hogs were engaged during the sinking of Caisson A. They worked in gangs composed of six men each, and the working day was six hours long—consisting of three hours on and three hours off before the second shift. At the start, only a few qualified sand-hogs were available, and the ma-

jority of the men were green and had to be trained.

The physiological effects of sustained air pressure upon caisson workers is a more or less absorbing topic with people engaged in this field of labor, and the following summary of this phase of the sinking of Caisson A is illustrative of what can be accomplished by the prompt and proper use of the hospital lock whenever any symptoms of "bends" develop.

Total number of decompressions, 10,500;

Total number of cases of bends, 17;

One case of bends to every 617 decompressions;

165 sand-hog foremen-days;

4,474 sand-hog laborer-days;

309 concrete man-days;

4,948 man-days under air;

Inspectors made 113 inspections under air pressure without developing bends;

Most cases of caisson disease affected the right knee;

Most cases occurred at the age of 34;

Youngest affected was 27 years old;

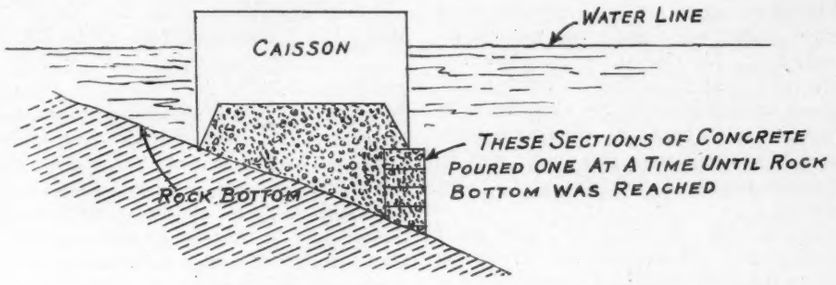
Oldest affected was 41 years of age;

Average time before symptoms appeared, one hour ten minutes;

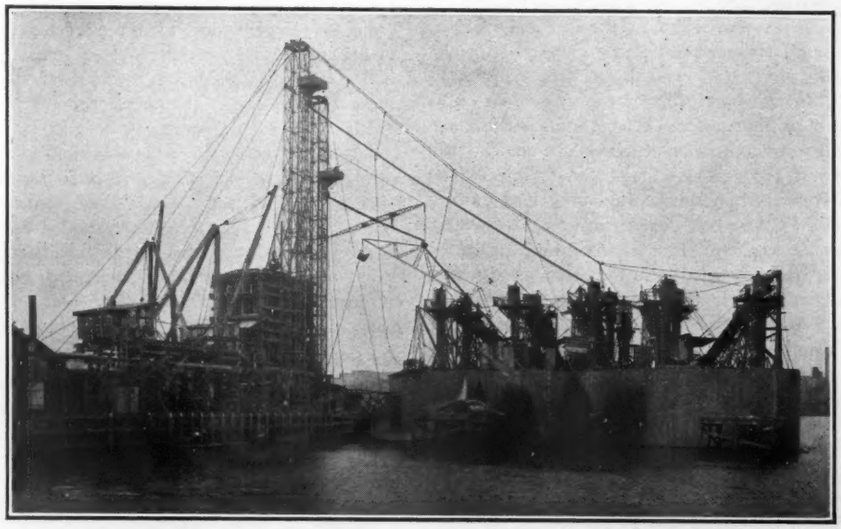
Most cases occurred when air was at 23 pounds pressure.

While sinking through soft material, the contractor was able to make a maximum advance of 28 inches in the course of 24 hours, and this involved the removal of substantially 925 cubic yards of sand and gravel. Not all of the muck was sent to the surface by way of the muck locks. Some of it was removed by blowing—the mud, sand, and gravel being forced to the surface through 4-inch and 6-inch pipes by the expulsive action of the air pressure in the submerged working spaces. At least one man was engaged a goodly part of the time in blowing. A measure of skill was required on the part of the worker in handling the flexible hose which was used at the intake or suction end of the blowing system so that it would not form a short circuit for the air. The caisson penetrated successively strata of mud, sand, and gravel before it came to rock. A layer of about ten feet of the latter, which was broken up by drilling and blasting, was finally traversed. When sinking through the rock progress was made at a rate of approximately nine inches in 24 hours. From start to finish the sinking and the sealing of Caisson A covered a period of 37 days.

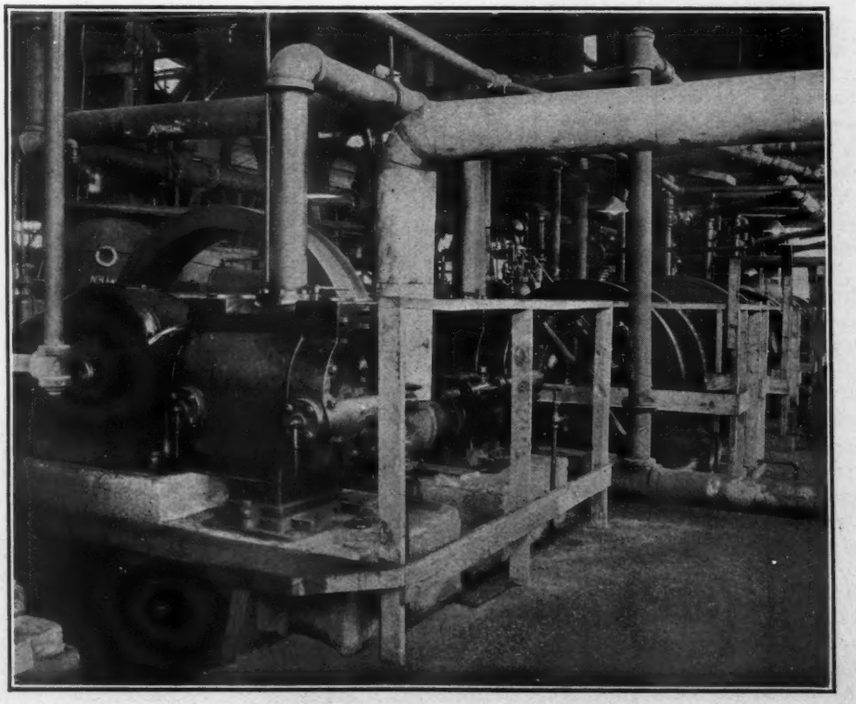
Caisson B, on the Camden side of the Delaware River, was moored at a point somewhat farther offshore than was necessary in the case of Caisson A, and at some distance out from the nearest pierhead. It was therefore needful to build a connecting link in the form of a temporary pier structure which would provide means for the distribution of material, a support for the running of essential piping, a ready path for workmen going to and fro, and an operative base contiguous to Caisson B for the concrete mixing plant and its associate chutes. With these facilities available, the sinking of Caisson B proceeded in substantially the same fashion as that followed in getting Caisson A down to solid rock. Air was applied to Caisson B on August 29. Mucking



Manner of anchoring Caisson A to rock bottom on ledge that dipped at a steep angle.



Caisson B, on the Camden side of the river, when about half way down.



The battery of compressors which furnished the compressed air during the successive sinkings of the two big caissons.

was completed on the 4th of October, on which date the sealing was begun. Air was cut off six days later. The caisson was brought to rest at a depth of 82.27 feet, and the entire operation was accomplished in the extraordinarily brief period of 36 days. As the figures show, Caisson B was sunk 24.15 feet deeper than its counterpart on the Philadelphia side of the stream.

During the descent of Caisson B mica schist was encountered. This varied from a relatively soft to a decidedly hard rock formation; and 30 feet of the softer ledge had to be penetrated before the rock became sufficiently hard to furnish the needful support for the pier foundation. The lower and harder rock was drilled and blasted, and 1,200 cubic yards of it was thus removed during the last stage of the sinking—"Jackhamers" being employed for the work.

As much as possible of the muck was excavated by blowing, and this procedure continued until gravel was reached. The muck was handled through 4-inch and 6-inch lines. The men engaged in this work had gained experience in Caisson A, and to insure success they had only to see to it that the mud and the water were mixed sufficiently to facilitate unobstructed passage upward through the pipes. The removal of muck in this manner has a good deal to commend it, because material can be dealt with well-nigh continuously and, of course, does not involve the use of air-locks, saving in this way considerable time and labor. Blowing, so it is said, is practiced far more extensively in caisson work in the West than is the case in kindred undertakings in the East.

When Caisson B was finally lodged upon the hard schist, its sealing was effected step by step after the manner initiated in dealing with Caisson A. At Camden, the concreting towers were 120 feet high, fifteen feet higher than those in use in connection with Caisson A, and there were two of these structures, each having a rated capacity of 45 cubic yards of concrete per hour. As indicated by some of the illustrations, the air-locks on top of the caissons were placed in two longitudinal rows, those in the outside row being twelve feet lower than the locks in the inner row. This difference gave proper clearance for the sloping chutes. When the caissons were sunk, and sealing was begun, concreting locks were mounted on top of the mucking locks, and both valves of the latter were left continually open in order to facilitate the rapid handling of concrete passing downward into the caissons. Tell-tale pipes were previously installed for the purpose of indicating the presence of undesirable air pockets in the accumulating mass of the plastic concrete. In this way grouting could be delivered so as to insure forcing out the air and filling up the cavities. This system of piping was originally used in part to carry low-pressure air to the working chambers.

The administrative personnel consisted of M. B. Case, senior resident engineer in general charge of the work, aided by Charles Elcock, assistant engineer. The general superintendent for the contractors is Daniel Hughes, representing the Keystone State Construction Company, and Carleton Greene is the engineer for the Holbrook Cabot & Rollins Corporation.

COMPRESSED AIR IN NORTH WALES LIMESTONE QUARRIES

By ROLAND H. BRIGGS

COMPRESSED AIR has made limestone quarrying in North Wales an important and profitable part of the industrial activities of the locality. The rock excavated from these quarries is carboniferous limestone, and it is regarded by geologists as part of the formation thrown down to the west by the great Vale of Clwyd fault. The stratum runs through an escarpment, which, although broken by various faults, extends from Ruthin to Llysfaen, and emerges, after a short interruption, in the boldly formed Bryn Euryn, near Colwyn Bay, and then at Little Orme Head.

The value of the limestone industry to North Wales is largely due to three factors: the quality and purity of the rock, the uniformity of its chemical composition, and the efficient mechanical methods used in quarrying it. The stratification of the quarries at Little Orme Head, well known to American and British visitors at the popular seaside resort Llandudno, is badly broken, there being every indication that a vast upheaval took place in this district at an earlier period in the earth's history.

The chemical composition of the rock obtained from the Little Orme quarries is of remarkable regularity, and analyzes as follows:

Silica	0.29
Alumina and ferric oxide	0.44
Lime	55.15
Magnesia	0.28
Carbon anhydride and water	43.84
	100.00

The high quality and the uniform chemical content of the rock make it valuable for the production of high-grade Portland cement, and the same factors render it suitable for blast furnaces and for the alkali industries. For the agriculturist the limestone is ground up exceedingly fine by modern pulverizing plants, which have been perfected in connection with the gold mining and the cement industries, and the modern fertilizer "Carbo Limo" is the result. It was a great American farmer who said, "Carbonate of lime is the sort that God put into the land when He made it. Burnt lime is man's attempt at improvement."

Whether raw, finely ground limestone or burnt lime is the most efficient fertilizer is for the agricultural chemist to decide; but it is certain that lime, in some form, is absolutely essential to the growth of all crops, especially to such varieties as clover and alfalfa. Both kinds of lime fertilizer are produced on the North Wales coast in their most efficient forms.

All of the drilling in the Little Orme quarries is carried out by means of compressed air. The working pressure is 80 pounds per square inch; and the big blast holes are drilled up to a maximum depth of 25 feet by drills of the piston type, while the boulder breaking and "pop holing" is done by hand "Jackhamer" drills.

Going eastward along the coast, one reaches the important limestone quarries in the neighborhood of Llysfaen. When the writer entered these quarries he saw an interesting example

Block holing limestone in a Welsh quarry by means of "Jackhamer" drills operated by a portable air compressor.

of the evolution of the mechanical equipment used in limestone quarrying in Wales. In one part of the quarry a tripod piston drill, driven by steam, was at work drilling big blast holes as it has done with unfailing regularity every working day since it was installed by the manufacturers, the Ingersoll-Rand Co., more than twenty years ago. In other sections of the quarry, portable, gasoline-driven air compressors from the same source were actuating the most modern types of "Jackhamer" drills. The air compressors are easily moved by hand to any part of the face where they are required; and during each blasting period, the "Jackhamers" are put on a trolley and the compressors are run back into a central garage out of harm's way. In other quarries, in this district, compressed air is supplied by a gas-engine-driven Ingersoll-Rand air compressor situated in a central power house, the compressed air being carried to the working faces by air lines in the usual way.

The limestone from the Llysfaen quarries analyzes as follows:

Moisture	.22
Carbonate of lime	97.50
Carbonate of magnesia	.84
Sand and insoluble silicates	.95
Soluble silica	.06
Oxide of iron and alumina	.24
Phosphorus	.01
Alkalies, etc.	.18
	100.00

The industrial uses to which the Llysfaen limestone is largely put are for the manufacture of soda ash, bleaching powder, and other chemicals at the large ammonia soda works in the Fleetwood district of Lancashire. A great deal of the limestone is also shipped, by sea, to Scotland, where it is much in demand for blast-furnace consumption, owing to its high percentage of lime and its low percentage of phosphorus. The limestone for chemical purposes and the lime for soap making are also largely delivered by water—the quarries having their private wharf to which the materials are sent by gravity from the quarries and limekilns; and vessels of as much as 900 tons burden can be loaded at this dock. More than 2,000 tons of stone and lime have frequently been shipped from this point in one day.

A goodly measure of the limestone from these quarries is converted into lime in the 3,000-ton, Hoffman kiln situated on the quarry property; and the lime made in this kiln is supplied to the large soap manufacturers for the production of caustic soda and for other purposes. The analysis of this lime is:

Lime	97.65
Magnesia	.80
Oxide of iron	.16
Alumina	.14
Silica	.51
Loss by ignition	.46
Trace of alkalies, manganese, etc.	.28
	100.00

There are many other interesting forms of limestone in North Wales in addition to the stone quarried in the Little Orme and Llysfaen areas. There is, for instance, the fine "jasper stone" found in the Aberdaron quarries in Carnarvonshire. This is a siliceous rock associated with crystalline limestone, with an addition of iron oxide. The limestone is associated wth the pre-Cambrian rocks which fringe the south coast of Carnarvonshire; and the "jasper stone" is a very dense rock of a rich crimson color. In Anglesea the carboniferous limestone series includes a compact, fine-grained limestone rock light brown in color, veined with darker streaks. This will take a good polish and, in consequence, is in demand for monumental work as well as for ordinary building purposes. The north coast of Carnarvonshire also produces good limestone for building purposes. Limestone is not extensively used in this area for road making, as its dominant mineral, calcite, is far too soft for efficient road service especially where traffic is at all heavy, while the remarkably valuable and durable igneous-rock roadstone extensively quarried in North Wales makes it a difficult matter for any other rock to compete with it.

In the preparation of this article, thanks are due to Mr. A. Tindal, manager of the Little Orme Limestone Quarries of the Ship Canal Portland Cement Manufacturers, Ltd., to Mr. J. T. Raynes, director of Messrs. Raynes & Co., Ltd., of Llysfaen, and to the Llandulas Quarry Co., Ltd., for their interest and help.

COMPRESSED AIR APPLIED TO THE MILLING MACHINE

COMPRESSED air has been put to very effective service in the machine shop of a western tractor plant in speeding up the milling operation on chain link-pins. The milling fixture, shown in the accompanying photograph, is pneumatically controlled. At each end of the fixture is a small cylinder, directly connected to the compressed air main of the plant. Each cylinder controls half of the fixture. A 4-inch, cast-iron piston, operating in the cylinder, has secured to its inner side a pointed plunger. This plunger engages the ends of two small bent levers, which are pivoted upon a common point.

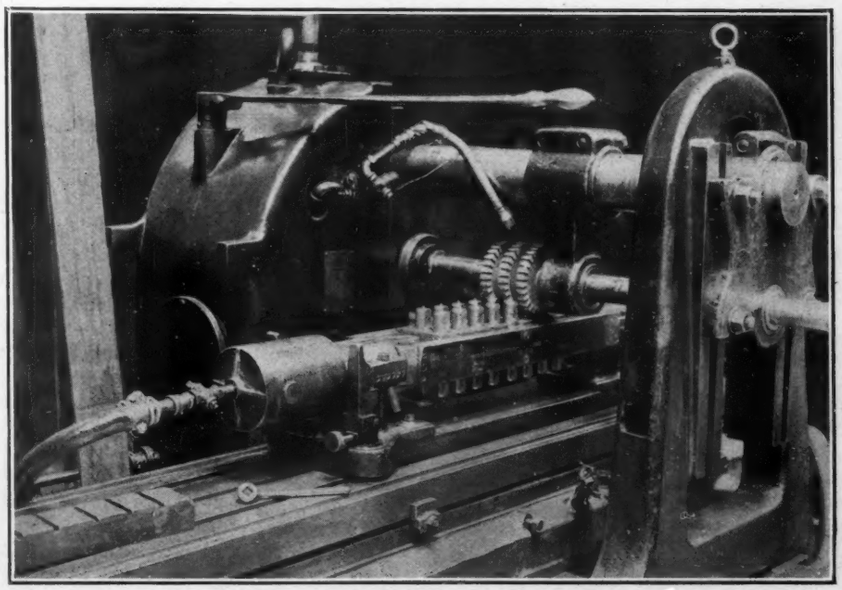
When air, at 100 pounds pressure to the square inch, is admitted to the cylinder, the piston and the plunger move forward and force the ends of the bent levers apart. The other ends of these levers thus transmit a greatly increased pressure to a set of four, movable holding-blocks located in the body of the fixture. As the blocks are forced together, V-shaped recesses tightly grip the round pins which are to be milled. When both ends of the pins have been milled, the air is shut off. The piston and the plunger are then moved backward by a spring. This releases the holding blocks and the pins drop out.

AN ECHO OF THE ARGONAUT DISASTER

AS IS SO often the case, public reaction to any catastrophe gives rise to much offhand and, on occasions, denunciatory criticism of the recognized responsible officials. Bearing this in mind, we are prompted here to quote a paragraph from the Oakland Tribune, Oakland, Calif., which has recently come to our attention.

"A false impression that California gold mines are peculiarly unsafe is one of the results of the Argonaut fire. Compared with coal or copper mines, the deep rock gold mine —as it is constructed on the Mother Lode, in reality, offers few hazards. Many of the mines are equipped with all of the known safety appliances, and, in addition, have what is known as wet shafts. The timbers here are always soaked. In addition, most of the deep mines have two shafts equipped with skips and ladders and a system of ventilation which cannot be blocked by fire or cave-in. It should be the duty of those familiar with the mining business to correct an impression which is having its effects on the industry here."

Benjamin Strong, speaking on "What's ahead in business?", says: "The wealth of nations does not consist of natural resources alone, or of population alone. It is the practice of thrift, the capacity for invention, that makes wealth."



Compressed air effectively used to help in holding round chain link-pins during their milling.

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EDITORIALS

The Season's Greetings

TO its old friends, to its new friends, and to those other friends it counts upon making, COMPRESSED AIR MAGAZINE tenders heartsome greetings, and wishes one and all of them the best of life's best in 1923.

May the New Year prove a happy one from beginning to end.

THE ENGINEER A FACTOR IN PROMOTING WORLD PEACE

IT IS HARDLY necessary to-day to dwell upon the splendid work done by engineers during the four years and more of armed strife; and yet in goodly measure it was their skill and devotion in their several lines of service that turned the tide of battle. Logically, by thus focusing attention upon their helpfulness in a very grave crisis, the public has been brought to realize the still larger field of usefulness open to these trained men in the years of peace.

Mr. CALVIN W. RICE, Secretary of the American Society of Mechanical Engineers, who participated not long ago in the International Engineering Congress at Rio de Janeiro, has told in a recent address what has latterly been accomplished by the engineers of the Western Hemisphere towards the unity of the Americas. Three important steps to this end have been taken, and they are as follows:

First, action has been initiated looking to the formation of a permanent organization to carry out the plans of the International Engineering Congress; second, a standardization bureau will be established in every Pan-American country; and, third, the long contemplated trans-continental railway is now nearing reality, for a meeting to further this project will be called at an early date by the nations of Pan-America.

These are big strides forward in the cause of international amity, and they are necessarily constructive because of the pursuits of the men immediately interested. With a common bond of service existing between the engineers of the two geographically wedded continents there must inevitably follow closer professional intercourse and still more cordial social relations.

THE PROPER HANDLING OF DRILL STEEL

IT IS ALWAYS gratifying to do a manifestly useful service. In a recent issue of the Magazine there was published an article, by an eminent authority, dealing with the forging and the heat treatment of drill steel, and the reactions to it have been highly gratifying. It is therefore to be hoped that by calling attention again to the subject we may be the means of reaching and of helping a still wider circle among those who have every reason to be interested.

Drill steel plays a prime part in a large number of the world's basic industries, and it is no less essential in carrying out a diversity of engineering projects which range from fairly modest undertakings to tasks of stupendous magnitude. Indeed, if we were to try to list all the ways in which drill steel is utilized by man we should have to give pages to bare statements of fact. Conversely, it is a matter of monetary concern, of outstanding economy, for the users of drill steel to know how best to handle it to get most out of it through long life and efficient performance.

The story of modern steels is one of the fascinating chapters of metallurgy. Even though the metal is capable of boring its way through very hard opposing substances still it is composed of elements which impose at times rather exacting consideration or treatment if the steel is to stand up to the stresses to which it is exposed when in action. Depending upon the temperatures employed during heat treatment and the manner of forging when forming or repairing a drill, the tool may be made either fit or unfit for the work expected of it. In other words, the blacksmith or the toolmaker has it in his power to transform and to ruin the physical properties of the finest of drill steels.

There is nothing mysterious about this, as is so frequently supposed. At least no one should find it hard to understand if he will read with reasonable care Mr. H. S. BRAINERD's lucid and comprehensive presentation of the subject in our November number.

PICKING FLAWS IN THE TARIFF LAW

MANY OF US have felt that the tariff law of to-day is not a happy solution of one of our great economic problems; but Prof. F. W. TAUSSIG, of Harvard University, has gone to some pains to point out how unhappy that legislation really is.

A short while back, in the *Quarterly Journal of Economics*, Professor TAUSSIG discussed the tariff act of 1922 in no uncertain terms, and he paid his compliments in rather plain English to the gentlemen in Congress responsible for its enactment. As that expert expressed it: "The tariff question is not settled. It is likely to remain on the political battlefield for years to come. And this is to be lamented. The industry of the country can accommodate itself to any system if once the system be settled. But constant vacillations are a great evil. They are not an intolerable evil, for the simple reason that the influence of the protective system on our industrial system, whether for good or ill, is not so far-reaching as most people think. But an influence it has, and that influence is particularly bad in so far as it is inconstant and incalculable."

Apart from the excessive protection to some groups of industries which the tariff law of 1922 affords, there is raised by the act that extremely vexatious question of foreign or American valuation of imported commodities, the aim being, of course, to establish a basis for the determination of production costs in equalizing the prices of competing foreign and domestic articles. Professor TAUSSIG asserts that it will always be impracticable to get correct figures relating to alien goods no matter what may be done here by the Government to ascertain the facts in our own plants. And he calls attention to the character of the discussions which consumed so much of the time of the Senate and the House of Representatives during the consideration of the bill.

To quote:

"Perhaps most noteworthy in the debates is the constant insistence by the sponsors of the act on the principle of equalizing costs of production. It is embodied for the first time in statutory language; it is declared by Congress to be the principle on which the tariff system is founded. Talk of this sort was more to the fore than at any previous time. And not only this: it was pushed to further extremes than ever before, both in the rates themselves and in their advocacy or justification.

"There were not wanting senators who expressed their willingness to impose a duty of 500 per cent. or 1,000 per cent. if such rates were necessary for the sacred purpose of equalizing costs of production. It seems to me extraordinary that sensible men should suppose that they had found here a touchstone for a scientific tariff or a practicable rule on which to proceed in fixing rates in detail."

And yet, with the uncertainties latent in the new tariff law, American business is expected to push confidently onward and to venture many hundreds of millions of the national wealth!

HIGH EFFICIENCY OF COAL PRODUCTION IN AMERICA

A LITTLE MORE than a year ago the *Manchester Guardian Commercial* printed an alarming article in reference to the British coal and steel industry. The statement was made that the cost per ton of coal in Great Britain was four times as high as in America. Figures were given showing that this was not a matter of wages but of output per ton per man. The *Commercial* estimated that in America each miner produced about 1,000 tons annually as compared with 200 tons per year produced by the British miner.

The National Industrial Conference Board has recently made some investigations on this subject, using the data furnished by the United States Bureau of Labor Statistics. These bring out the striking fact that the productivity of the American mines has for a long period far exceeded, and still exceeds, that of the mines in any other country. The Industrial Board makes the statement that the average yearly output per man has risen almost steadily from 421 tons in 1889 to 743 tons in 1920. The figures further show that the annual output of coal per man in the United Kingdom has almost steadily declined from 318 tons in 1885 to 147 tons in 1921. A similar decline is noticed in Belgium. In Australia, South Africa, and Canada the output has increased, while in Germany, France, Russia, Austria, and Spain there has scarcely been any change throughout the period mentioned.

Apart from the fact that there is a great difference in mines, and that the output per man would, therefore, be less in some mines than in others—especially in the older ones, yet the figures lead to the conclusion that a large part of the advantage is due to the use of machinery, which invariably increases the output tonnage per man.

PRICE CYCLES

BUSINESS moves in cycles composed of big waves, smaller waves, and diminutive waves which are not much more than ripples. The plotted curve of commodity prices plainly shows this. During the past 110 years we have passed through two distinct major price cycles, and are now in the third; but all this time we have been making innumerable cyclets. The crests of the major cycles occurred in 1812, 1864, and 1920, and their peaks were almost of exactly the same height. The low points between them were also nearly identical; and from each peak to each "low" was just about 30 years. So much for the past.

The present major cycle is less than three years old, and prices have fallen sharply from the crest. If there is anything in analogy it should be many years before the bottom is reached, but, in point of fact, a very decided bottom has already been reached and prices are again advancing. Are they advancing to close a major cycle far ahead of the date on which it is due, or is it but a minor cycle that is being closed?

There is a school of economists which firmly believes that we are in for a long pull of slowly declining prices, and which regards the present rise as but an incident in one of the minor cycles that are constantly occurring. It warns us to stop thinking in terms of rising prices—to which we all became accustomed in the long steady advance from 1897 to 1920—and to turn our minds toward terms of falling prices.

On the other hand, an equally positive school maintains that the so-called "quantity theory" of money and prices, which has stood the test of centuries, is still in force. This teaches that the more money there is in circulation, in one form or another, the higher the prices will mount. This country has more gold now than it, or any other country, ever had before. So long as it remains here it is a potential worker for higher price levels because it tends to promote credit inflation and credit inflation is a sure forerunner of price inflation.

Between these two opposing theories the business man must choose, but as prices rise, whether it be in the making of a minor or a major cycle, it is a signal that there is danger ahead somewhere—danger which may result in a crisis if, indeed, it is a major cycle that now approaches completion—and the public, which probably never heard of either theory, is going to have the say which of these it is to be.

THE PADLOCK SOCIETY

THERE IS a society in England, sponsored by Dr. ARMSTRONG SMITH, the object of which is to do away with carelessness in speech. Its members "promise to try their utmost never to say an unkind thing about anyone, whether true or not." It is called "The Padlock Society;" and when the oath of membership is taken the key in the lock is turned, and that's all there is to it. There are no fees, no dues, no penalties. America extends an invitation to the organizer of this society to visit these shores, for in no other country is carelessness of speech more prevalent.

Scandal is the hall-mark of dishonesty. It is the near-lie from which no man can protect himself. The idle remark, based on half-knowledge and half-truth and made by the speaker heedless of the effect produced, denotes an absence of order in the mental machinery. A white lie is often more dangerous than a black one; the spoken word more insidiously harmful than the written one; and the poison tongue more to be feared than the poison pen.

The capacity to do harm possessed by the village gossip is appalling. The story told by the idler in the country grocery; the sweet bit of muck of the man-about-town recounted at the club; the tea-party fling at some non-present neighbor, all have in them potential dynamics making for individual and social degeneration. Speech, in its effect, is like the widening ripple on the water when stirred by a pebble thrown upon its surface. Its influence for good or ill is unending.

The Padlock Society might well also turn its attention to the tale-hearer—to the unthinking or malicious passer-on of gossip, rumor, or scandal. There are plenty of men and women in social, club, and business circles who glory in the publicity they thus obtain. Their little brains holding nothing interesting, instructive or brilliant to impart, these persons obtain the floor by repeating or inventing something damaging to the reputation of an absent fellow. It is no easy matter to win and to hold a good name so long as the scandal-monger is abroad to blow out slander with a venomous breath—with a *sub rosa* word, which is listened to all the more attentively because it is *sub rosa*.

Persons of bad repute were ostracized by the ancient Greeks, but not upon the testimony of the gossip and the tale-bearer. It was only after weeks of deliberation by their councils, in the light of facts, that the power was exercised. Yet, to-day, it is possible to banish, to damn, to socially murder an innocent member of a community with a word, that has no foundation, spoken spitefully.

Society has tolerated the gossip for ages. Instead of being looked upon as an enemy of mankind to be ostracized he is often countenanced and encouraged. Men and women like to listen to him, to believe, and to pass on again and again his vitriolic half-truths. It is a low stage of culture that would prefer to believe ill rather than good of a man—that would rather see him fall than rise. It is a low stage of intellect that worships at the shrine of its own ego—that is willing and anxious to bear witness that he is not like others. He is a Pharisee.

DOCTOR SMITH proposes to banish him from London society. All right-minded American men and women will welcome his ostracism from their social and business midst. He is not wanted. Out with him! And the world will be better, cleaner, and more livable.

The Padlock Society asks for charity; pleads that its members eliminate rumor and substitute fact; that they weigh their words as they would weigh fine gold; and that they remember the Japanese couplet:

"The bird of an idle word hath flown from thee;
Not ten thousand horses fast, could o'ertake it as it passed."

WAGES AND PURCHASING POWER

SOME INTERESTING figures have been published by the Bureau of Foreign and Domestic Commerce, Washington, on wages and purchasing power which make a comparison between those for the years 1914-1920 and those for 1921.

In the case of most of the occupations listed, the decline in wages or salaries has so far been less since 1920 than the decline in the cost of living, and, therefore, the purchasing power of wages was greater in 1921 than in previous years.

To cite some of the occupations, taking the purchasing power or the relation between wages and cost of living in 1914 as 100, then the purchasing power for machinists in New York City in 1920 was 109, and in 1921 it was 140. Unskilled labor in New York, on the same basis, had a purchasing power in 1920 of 110 as against 122 in 1921. For factory workers in New York the figures were 115 in 1920 and 126 in 1921; and for railroad employees 102 in 1920 and 115 in 1921.

The figures are reversed in the case of employees of the Federal Reserve Bank of New York, of librarians in Congress, Government employees at Washington, railroad officials, cabinet officers, and senators. In these occupations, taking 100 as the basis for 1914, (in the case of the Federal Reserve Bank of New York the basis is 100 for 1917) we find the average for 1920 to be about 75, and for 1921 about 90. The figure reaches as low a point as 61 for cabinet officers and railroad officials, showing that in the case of these occupations the purchasing power, measured by the salaries, is considerably reduced.

THE AIR LIFT— AND AIR LIFTS

AN ESTEEMED correspondent, in the December issue of this Magazine, finds only error in our little article on *The Air Lift—and Air Lifts*, which appeared on page 289 of the October number.

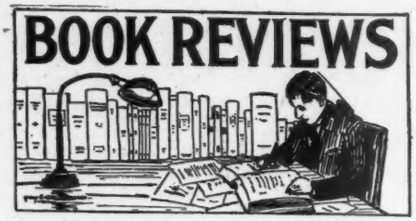
The purpose of the article was to call attention to the confusing use of "air lift" and "air hoist" and to suggest that air lift should apply only to the now familiar water elevating device and that air hoist should be used for the raising of solids. If this purpose was not clearly indicated and as clearly understood the writer and the reader can mutually regret it.

We stated, and we still think, that the term air lift does not describe and is misleadingly suggestive of the function of the air in the device under consideration. At the same time we distinctly declined to suggest a more correctly descriptive term, because we were unable to do so. Space will not permit us to discuss this matter more fully here.

The several Pohlé patents are, officially, for an "Apparatus for Elevating Liquids." It became known at once by the public as the "Pohlé Air Lift;" but whether Doctor Pohlé was the first to apply and employ the term does not appear. He was notoriously wrong in his theories and in the descriptions of the principle and functional operation of the device: so much so that it may well be questioned whether he was by knowledge and attitude competent to correctly name it. The name, however, is bound to stick to it, and it is obviously best for us to use the name "air lift" for that and for nothing else.

An invitation has been issued to American manufacturers and merchants to attend an international commercial exposition to be held in Osaka, Japan, from March 31, to May 31, 1923. This offers an excellent opportunity to exhibit to the Japanese such of our products as are in demand by them and which include hardware, tools, machine tools, machinery of all kinds, industrial supplies, etc., etc. As the exhibits are not to be returned, but are to be placed permanently in the Commercial Museum of Osaka, it is suggested that samples be sent only of the less expensive products and that models be shown of the larger and costlier machines, etc.

Brussels, Belgium, is to hold her fourth Official Commercial Fair this year from April 9 to 25, inclusive.



THE SLIDE RULE applied to commercial calculations by R. M. Shireby, 66 pages, with suitable illustrations. Published by Sir Isaac Pitman & Sons, Ltd., London. Price 85 cents.

THE SLIDE RULE, as an aid to engineers and other technical men having recourse to mathematical computations, is a commonplace, but the average man in business life has not recognized heretofore that this time-saving instrument could be used by him to advantage. Mr. Shireby has set himself the helpful task of showing how the slide rule can fit into commercial activities, and he has succeeded admirably in his numerous examples.

The book has been written for those who, in the course of their daily office routine, have numerous small calculations to work out, and who seek an easier method of dealing with them than that of ordinary arithmetical procedure. The presentation of the subject is in clear and simple language and, accordingly, easy to follow and to comprehend. The book is the outcome of ten years of daily experience with the slide rule in commercial life, and, therefore, is not a mere theoretical offering.

WHY MANUFACTURERS LOSE MONEY, by Robert Grimshaw, 176 pages. Published by D. Van Nostrand Company, New York. Price $2.

THE PRESENT book is the outgrowth of various lectures on cost reduction delivered by the author both in Europe and in the United States during 1913 to 1916, inclusive. While the work does not pretend to cover the ground exhaustively, or even concretely, it does name substantially all of the principal and most of the minor causes of loss, and to this extent it offers food for thought and a guide to corrective measures. Most manufacturers would probably profit by reading the book and by applying the lessons that are lucidly presented.

RAILROAD FREIGHT TRANSPORTATION, by L. F. Loree, president, The Delaware & Hudson Company, 771 pages, with illustrations. Published by D. Appleton & Company, New York. Price $5.

THE AUTHOR has packed into this book a wealth of valuable and informative material, and has put at the disposal of the public at large the presentation of a vital topic about which the vast majority of our people know but little. The transportational situation in the United States has come to a critical stage, and while the experts will probably be able to solve the multiple difficulties now confronting them still they will undoubtedly be able to do this all the sooner if more of our citizenry have an intelligent grasp of the problems involved.

As Mr. Loree points out, the United States, in its large and compact territory, possesses more than half of the world's sources of power —coal, oil, and hydraulic—and more than half the sources of the great basic minerals—iron, copper, lead, and zinc. It dominates the world's markets with the great staple commodities—cotton, wheat, and meats. The rapid growth of the population, the great areas over which it is spread, and the character of its activities have led to a great development of freight transportation upon steam railroads. This development has, in turn, made possible a growth of industry and commerce not even remotely approached in any other country.

The purpose of the book is to assemble, in reasoned order, all of the phases of loading, distribution of cars, movement of engines and trains, handling of men, the features of permanent way and shop plant, the organization through which they are controlled, and the accounting made of their activities—as they are related to transportation. Certainly a comprehensive field of study; and Mr. Loree has made his treatment of it absorbing and informative in all of its phases.

SHIELD AND COMPRESSED AIR TUNNELING, by B. H. M. Hewett and S. Johannesson, members American Society Civil Engineers, 465 pages, profusely illustrated. Published by McGraw-Hill Book Company, Inc., New York. Price $5.

SUBAQUEOUS tunneling by means of compressed air and the hydraulically operated shield has played an important part during the last three decades in facilitating more rapid intercommunication between sections of populous cities or between neighboring cities and contiguous areas contributing a daily movement to and fro of great numbers of transients. Probably no single municipality has afforded the engineer a wider opportunity in this special field of construction work than the City of Greater New York; and the authors of the present volume have drawn generously upon their practical experience in this particular neighborhood in presenting the subject.

Much has been learned since compressed air was first applied to tunnel work in 1879, and yet nothing new dealing comprehensively with this important branch of engineering has appeared in book form since 1906. However, a great deal has actually been done in the building of subaqueous tunnels in the meantime, and the purpose of Messrs. Hewett and Johannesson is to cover some of the outstanding accomplishments of recent years. Their intimate association with the driving of the Hudson River tunnels for the Pennsylvania Railroad has given them a wealth of first-hand data, and they have drawn generously upon this store of material in preparing their book.

As the authors express it: "So much tunneling has been done with the aid of the shield and the art of such work has been developed to such a point that it is possible now to formulate, to some extent at least, certain principles and rules of practice on which to base the design and construction methods of future work." The library of every engineer engaged either directly or indirectly in this type of construction should include a copy of this volume.

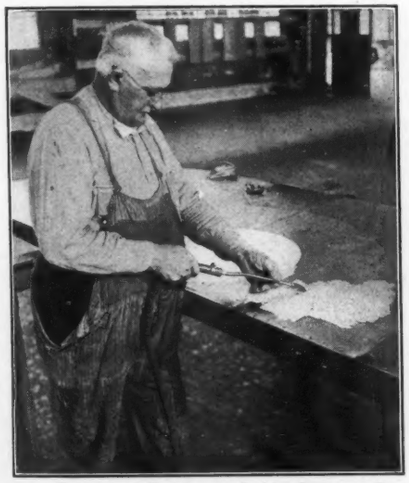
Pacific port figures show that San Francisco leads Seattle in the matter of shipping. In cargoes cleared the margin is but a small one, but in the case of cargoes entered the California seaport is far ahead.

REMOVING PAINT BY MEANS OF COMPRESSED AIR

THE MODERN method of painting is by spraying with compressed air; but now a Philadelphia inventor has gone a step further and also employs compressed air to remove old paint before repainting. This is accomplished by a scraper, to which is attached a hose supplying a jet of compressed air. In this way the old paint and blisters are removed so fast that the work seems like magic.

Paint is usually removed by scraping or by burning and scraping. This is tedious and expensive work as the painters must be paid to take off the old paint as well as to put on the new. Think of the painter standing on a ladder for hours with a torch in one hand and a scraper in the other, slowly burning and scraping away at the old paint. And then imagine the painter using the compressed air scraper. With it the loose paint is actually blown off in patches.

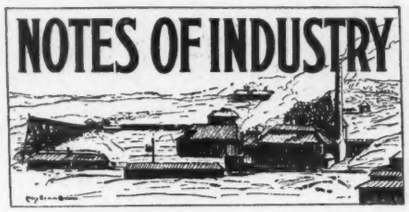
This novel scraper effectually removes the old paint and blisters but does not take off the paint that has been absorbed by the pores of the material. This is an advantage, as such paint makes an excellent smooth ground for the new coat and calls for less paint than when the old paint is completely burned off.



Courtesy, Compressed Air Scraper Co.
Using the pneumatic scraper to remove paint from a fabric surface.

The compressed air paint scraper is a special tool which consists of a metal tube and a scraper, which has an air outlet in its bottom surface about one inch above the cutting edge. Compressed air is fed to the tool through a hose connected to a portable compressor. To remove paint from a surface, the object is to get the scraper under the paint at one or two points, and then the lifting force of the air literally blows the paint off in flakes.

Secretary Hoover, of the Department of Commerce, and representatives of the states concerned have signed an agreement for the development of the Colorado River. Before it can become effective, however, approval of the agreement by the legislatures of the states and by Congress must be had. Besides the development of hydro-electric power, the agreement provides, among other things, for the use of the water for mining purposes.



Over two-thirds of the rubber produced in the world goes into the making of pneumatic and solid tires, including inner tubes. Some five or six pounds of crude rubber is said to be the average quantity put into a tire.

A copper mine that was worked by miners of the Stone Age has been found on an island near Port Arthur, Ont., Canada. The shafts or pits were twenty to 30 feet deep in the solid rock, and the tools which were evidently used were black, egg-shaped stones of great hardness.

The city of Greenfield, Ind., is up and doing and believes in employing the most modern facilities to do its work about town. Compressed air has recently been put to the novel use of cleaning out the drinking fountains in that community.

Development of the iron deposits in the Valle di Aosta, Italy, by the Ansolda Company was one of the great undertakings begun under pressure of war necessity. The principal problem in opening up the deposits was one of transportation as the ore had to be taken to Aosta, where electric furnaces were built. This was solved by driving a tunnel through the mountain that barred the way. This tunnel, which has a length of a little more than 4 1/3 miles, has just been completed and took six years to build.

From figures just compiled we learn that the late coal strike has cost the country $1,190,000,000 or more than $45 per family. Divided up, this means $450,000,000 in lost wages to miners; $300,000,000 loss to the railroads; $400,000,000 that the public must pay in the way of added cost of fuel; and a loss of $40,000,000 to the operators.

Owing to the ever-menacing presence of fire damp in coal mines, the French laws forbid the use of electric or gasoline locomotives there so as to prevent explosions from those sources. For that reason compressed air locomotives are generally to be found in the coal mines of France.

It is of interest to learn that from an import nation in the matter of lenses we have in the last few years become an export nation. The majority of the lenses for spectacles and eyeglasses sold in South Africa are imported from the United States.

A duty of 10 per cent. has recently been levied on motor vehicle imports into Mexico and this money is to be spent by the government for the building of roads.

Thirteen dollars a month, or 26 gold rubles, is the salary of a master machinist in the Russian industry under Soviet rule. Its purchasing value is equal to eighteen gold rubles of prewar times.

According to statistics issued by the Commonwealth, the population of Australia has increased from 4,573,868 in 1911 to 5,510,229 at the end of 1921. This is an annual increase of 1.87 per cent.

The island of Ceylon has at present approximately 2,500 miles of roads, which are inadequate for the traffic there. Attention to this situation has been called by the large increase in the number of commercial motor cars now in use in Colombo and elsewhere. The policy of the Public Works Department of the island is to encourage motor traffic, and to this end an increased appropriation of about $220,000 has been asked for road maintenance.

It is estimated that 75,000,000 H.P. is being drawn upon to turn the industrial wheels in the factories of the world, including electric lighting and street railways. The world's railroads use 21,000,000 H.P., while the shipping on the Seven Seas needs 24,000,000 H.P. to keep it going.

The first all-steel sleeping cars in Europe have been put in service by the International Sleeping Car Company, and are sent by train ferry from Hull to Calais, and *vice versa*.

The Ingersoll-Rand Company and The A. S. Cameron Steam Pump Works announce the opening of a branch office, 718 Ellicott Square Building, Buffalo, N. Y. This new office is fully equipped to serve those interested in air, gas, and ammonia compressors, vacuum pumps, turbo-blowers and compressors, condensers, oil and gas engines, pneumatic tools, rock drills, centrifugal and direct-acting pumps, and in numerous other products manufactured by these companies.

Considerable interest has recently been aroused in Germany over the question of a new motor fuel; and claims have been made by a professor of the Technical High School in Berlin, to the effect that he has perfected a new method of obtaining gasoline from a crude oil which depends upon unusually high pressures.

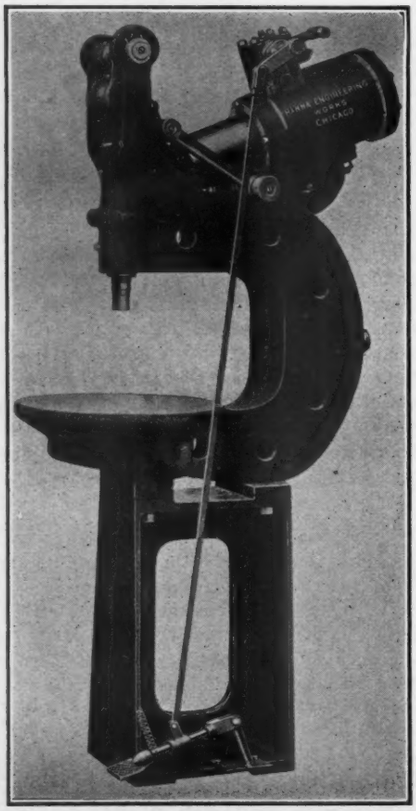
According to the latest statistics available, the United States imported 43,365,763 bunches of bananas in 1921. Not so very long ago this fruit was sold in this country, wrapped in tinfoil, at ten cents apiece, and was considered a tropical curiosity. So much for what cold storage, among other things, has done to make this possible.

Through the irrigation of 19,000 additional acres of land in middle Java the sugar production of the Dutch East Indies is to be increased measurably.

HANNA PNEUMATIC TOGGLE AND LEVER PRESS

IN MARKING, embossing, and coining, and in certain types of forging, exact uniformity of results is necessary in order to turn out an acceptable product. This means that there must be not only a very nice control of the operative pressure but that the measure of pressure shall be susceptible of adjustment to meet the distinctive requirements of each type of job. These desiderata have been met in a general utility press, operated by compressed air, which has been developed by the Hanna Engineering Works of Chicago, Ill.

The press, shown in the accompanying illustration, is equipped to compress or pack in pots carbonizing material around parts which are to undergo case-hardening. It is, therefore, admirably adapted to the needs of manufacturers engaged in the production of heat-treated gears, forgings, automobile parts, etc. Owing to the fact that the machine is arranged to be fitted, as required, with various forms of platens, tables, or other structures for the support of the work, it is practicable to utilize it for straightening, bending, forcing, marking, embossing, forging, briquetting, multiple riveting, and allied services.



An adaptable pneumatic press.

The machine is so designed that the length of the die stroke is variable; but, no matter where the die travel stops, no more than the rated pressure is exerted by the die. The connecting mechanism between the die and the actuating air piston, being a combination of toggle and lever, causes the air piston while moving at a uniform speed to impart to the die a gradually decreasing speed and an increasing pressure during the first portion of its stroke and, conversely, insures a substantially uniform speed and pressure during the last portion of its stroke.

The first portion of the die stroke ranges from 1½ inches to 4⅝ inches in length, depending on the pressure rating of the machine. The last portion of the die stroke is from ⅜ inch to 1⅛ inches long. The press is built of the following tonnages: 15, 20, 30, 50, 70, 80, 100, 125, 150, and 200.

When employed for binding and straightening, the machine has this advantage: the pressure on the die increases only as the air pressure is built up on the operative piston. Because of this feature, it is practicable, by throttling the air and thus raising the pressure slowly, to apply to the work just sufficient pressure to effect the desired deflection and then to release the pressure at once.

Should the die travel be stopped by the resistance of the work at any point within the uniform pressure stroke, which is anywhere beyond half piston stroke, then the pressure on the die is of a predetermined amount and in direct proportion to the air-line pressure. The air-line pressure may be controlled by the regulating valve within 5 per cent. The operating valve may be actuated either by hand or by foot. As may be seen, this press is another evidence of the flexible, cushioning action of compressed air and of the peculiar virtues of this form of energy which fit it for a wide range of special services.

ACCIDENTS UNDER ABNORMAL AIR PRESSURES

By ROBERT W. JONES

FOR MANY years we have heard of the great danger and high accident rate wherever men are engaged in tunnel construction under the abnormal air pressure necessary in driving through material under hydraulic pressure. In most cases, where an investigation of accidents has been carried on, greater attention has been paid to the prevalence of caisson disease than to the usual class of accidents occurring in the building of tunnels under normal air pressure. There seems to be a general feeling among engineers, who have had little experience in air work, that if the construction is being carried on under the protection of a rock face conditions are safer than when the tunnel is being driven through soft material. This is seldom the case.

No attempts have been made in the past to properly classify accidents under abnormal air conditions or to draw a comparison between the accidents under abnormal and normal air conditions. In the collection of accident statistics on work under both normal and abnormal air conditions there has been a lack of information as to just exactly what constitutes an accident. A nail puncture of the foot may not be classified as an accident, and yet this laborer may, in a few days, be laid up with an ugly case of infection. Besides the usual run of accidents, it would seem that the unnatural conditions of work under air pressure might have some effect on the nervous system of the laborer and thus lead to accidents peculiar to these conditions.

The following general figures have been taken from the accident book of a corporation recently engaged in tunnel construction under conditions remarkable for the high standard of work and the high air pressures. Every man who was injured, no matter how slightly, was expected to report to the doctor, and a complete record of all accidents was kept. The record, as given, covers only a period of 170 days, from January through June. During this period the air pressure varied from 21 pounds to 47 pounds per square inch, gage pressure. There was a steady upward rise in pressure, reaching a maximum in June.

	Accidents	Hospital Cases	Deaths
Powder fumes	1	..	..
Electric burns	2	2	..
Pinched by tools	2	..	..
Fights	3	..	..
Failure of tools	9	1	..
Nail punctures	13	..	..
Miscellaneous	14	3	..
Eye injuries	16	2	..
Falls	18	5	..
Falling rock	21	4	..
Falling tools	29	3	..
Transportation	35	2	1
Caisson disease	58	5	1

The percentage of accidents resulting in hospital cases was 8.6 for caisson disease and 13.5 for all other injuries. The preceding table is a typical example of what occurs in tunnel construction work under air pressure. The law and the codes relative to air work are as complete as it is possible to make them and are rigidly enforced. The results are shown in the low rate of caisson disease hospital cases. It is necessary to go back only a few years in compressed air work when a case of "bends" was commonly serious. Within the last few years there is on record but one death caused by working under high air pressure while in the early days of this method of tunnel building the death rate was twenty. The classification of accidents in the preceding table is partly self-explanatory. It may seem strange to include "fights," but in these cases some of the bad feeling aroused may be directly traced to the abnormal air conditions. The cases included under the heading "miscellaneous" were almost entirely due to changes in temperature, resulting in colds, etc., which, properly, are also to be classified as accidents. Transportation accidents were generally brought about by shifting of the tracks which caused cars to jump or switches to fall, and, not infrequently, they were also the result of failure to observe hoisting regulations. Caisson disease varied from a slight pain to cramps, dizziness, paralysis, and death.

When conditions are taken into account it will be recognized that the accidents, as listed, are not excessive. In ordinary tunneling operations, under normal air, there would not be over three changes of shift in 24 hours, but in the case of the work under higher pressure, when the accidents were listed, the length of shifts varied from eight hours per 24 to 90 minutes every 24 hours, with the 90-minute period dividend into two shifts of 45 minutes each and with a 5-hour interval between shifts.

There are 92 sugar mills now operating in Mexico.